

GENETIC PSYCHOLOGY MONOGRAPHS

Child Behavior, Animal Behavior,
and Comparative Psychology

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Child Behavior, Animal Behavior,
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A CRITIQUE OF SUBLIMATION IN MALES:
A STUDY OF FORTY
SUPERIOR SINGLE MEN

By
W. S. TAYLOR

Worcester, Massachusetts

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The principal conclusions of the study were outlined before the Ninth International Congress of Psychology, New Haven, September 3, 1929, in a paper called "The Psychology of Personality and 'Sublimation.'" A more complete discussion of the part on alternative response was presented at the Twenty-first Annual Meeting of the American Psychopathological Association, Boston, May 29, 1931, and was published in *The Psychological Review*, under the title, "Alternative Response as a Form of 'Sublimation,'" in 1932. Other, brief, portions appeared the same year, as "The Inadequacy of 'Sublimation' as a Concept for Ethics," in *The International Journal of Ethics*; and "Expression and Restraint," in *Mental Hygiene*; while the following were in press: "Criticism of Sublimation," *Character and Personality*; "Sources for the Regard for Celibacy," *The Journal of Social Hygiene*; and "Intentions as Urges," *The Journal of Abnormal and Social Psychology*.

W. S. TAYLOR

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I

INTRODUCTION

Prejudices, fears, wishes, pretenses, rationalizations, amnesias, have allowed too little scientific knowledge of the psychology of sex. The field, however, is important, both practically and theoretically. A proper task for us is to avoid, on the one hand, the Scylla of romantic over-valuation of sex, and, on the other hand, the Charybdis of that head-burying which we commonly ascribe to ostriches.

The aim of the present study is to examine the psychoanalytic conception of sublimation, to test its theoretical and practical validity in young men chosen for their apparent general superiority, and perhaps to contribute toward an understanding of masculine sexuality.

Changes in the subjects' styles of statement and in irrelevant details of their histories, also frequent use of quotation marks for spoken reports which were not taken down *verbatim*, will be understood as means to impersonal yet essentially accurate record.

II

THE THEORY OF "SUBLIMATION"

One of the most significant developments in the psychology of sex, according to many students, is the conception of "sublimation." "Sublimation" means a diversion of "sex energy" into "higher forms" of activity. As evidence that this sublimation occurs, the proponents of the doctrine point to numerous artists' productions which are said to have sprung from romance; and they call our attention to the long array of philosophers and saints who, like many other persons, never married, but lived spiritually fruitful lives. Perhaps the most convincing of all the examples is the woman disappointed in love who turns to the convent for a life of religious devotion and charity. The conclusion is readily drawn by many contemporary lay readers of psychoanalysis, and by a number of teachers and practitioners, that "complete sublimation of the *libido*" is possible; that any normal individual can discharge into ethical and cultural outlets not only the "psychical and spiritual sides" of his sexuality, but "the physical," too. These theorists infer that the process of sublimation is psychologically sound, ethically desirable, and of great significance to economists and sociologists as well as to physicians, psychologists, educators, and the people generally.¹

¹The idea of sublimation is not new. Ellis (25, pp. 51 ff.) traces its history in England from Drayton, Davies, and Jonson down. Nor is the notion limited to psychoanalytic circles. Shaw (108, p. c) speaks of the "immense numbers" of people who have "saved their

In the light of this theory, any uncommended form of sex outlet is a failure to sublimate. Masturbation,

energies for less primitive activities" than sex. Cabot (9, p. 14) refers to the process of "working off . . . sexual tension" by means of "exhausting labor out of doors," or by "rushing and hurrying about"; and a common view in school circles is that when it comes to masturbation, for example, boys should be taught that "the growing physique and developing mentality require all the vitality that the normal body can produce" (Fielding, 29, p. 172).

Ovid (86, p. 468) advised that "you who seek a termination of your passion, attend to your business; . . . soon will voluptuousness turn its back on you." At the other extreme of erotic perspective, a little pamphlet published for circulation during the War stated that "in the first place, continence or the curbing of the sexual impulse is possible. There is today a body of men who, it must be admitted by all, are second to none in bodily health, manly vigor, and intellectual strength. I speak of the Catholic priesthood. They are bound, not only to continence, but to absolute repression of the sexual impulse.

"Continence is, moreover, recognized as a source of strength. It is known that the gladiators of Rome, who were trained to the second for their deadly combats, were not allowed to waste their seminal fluid. It was known, even then, that sexual intercourse or any substitute for it, such as masturbation, had a depressing effect on the whole body" (Sloan, 111, p. 16).

Addams (1) remarks that the experience of those who have worked with young people, adolescents especially, shows the advisability of keeping their emotional life diffused and utilized through the imagination. William Lee Howard sets forth the contentment and continued youth of the unmarried woman of today who is interested and enthusiastic in her work and altruistic interests (quoted by Robie, 100, p. 246). Psychoanalytic influence is evident in Tead's (118, p. 41) reference to "a real diversity of possible ways for the instincts to function," and in McDougall's (70, p. 91-92) conclusion that the real function of sex taboos is "to restrain the sex impulse and lead to its sublimation."

Similar statements appear in a recent book based on the deliberations of the Commission on the Relations between College Men and Women, a commission appointed by the Council of the Student Young Men's and Young Women's Christian Associations, to represent many points of view now current. In this book, although "sublimation" and "substitution" are avoided as unsatisfactory terms, the

in particular, is doubtless "a normal phase of growth," but a phase which, if persisted in, represents "arrested

reader is advised that "the most humanly satisfactory expression of the sex impulse will be . . . partly direct and partly indirect." Here "the indirect expression of an impulse does not mean the elimination or destruction of the impulse, but merely its transformation into a different kind of expression." Thus in the sexual intercourse of married people, "the mere physiology of the act may be thought of as *direct* expression, and all the sentiments and feelings of love and tenderness which accompany it may be thought of as the *indirect* expression of sex"; "tenderness, understanding, and the whole range of intimate responses can be expressed between them in other ways than by the sex act." It follows that "in the case of those who do not marry because some task absorbs them completely, there is little problem of what to do with surplus sexual energy; it is used up in their work" (Elliott and Bone, 23, pp. 4, 5, 13, 16).

In the opinion of Riggs (96, pp. 105, 107), although "perhaps there is no entirely satisfactory solution for the high-minded and ethical unmarried," "it can be said with absolute confidence that a fully occupied purposeful and friendly life lived with reasonable regard to physical hygiene makes it possible for any woman or man to live without direct and specific expression of the mating instinct. The force of this instinct can be used in, and as it were absorbed to a large degree by intellectual, social, and artistic effort or any other emotionally satisfactory, purposive, and sufficiently demanding occupation."

We shall have to consider later the important truth in Riggs's (96, pp. 107-108) further statement that "in order to effect this transference of power successfully and smoothly the individual must first have understood the problem, faced it frankly, and accepted it fully; then the mating instinct, together with all the others, will lend its force to a wisely planned, well-balanced, constructive life and will no longer torment its possessor." For it is certainly true that, granting Riggs's terminology, "it can also be said with equal veracity and emphasis that, for either sex, a purposeless, self-indulgent, unoccupied, and unhygienic life makes it a thousandfold more difficult to control *any* instinct and especially that of sex."

Orthodox psychoanalytic statements of sublimation occur in Frink (35, pp. 19, 146-148, 268, 552); Hall (38, Vol. 1, p. 469 and *passim*); Henry (46, p. 18); Roback, a critic of psychoanalysis (97, pp. 147-148, 161); Kempf (58, p. 153); Wells (121, index); White (126, p. 278); Fielding (29, pp. 262, 285, 286); and in Menzies

erotic development," and if recurring in the adult is "reversion to infantilism." Thus the long-established

(76, pp. 24, 86, 93-95), where citations and further references may be found. As a writer to the *Springfield Republican* put it: "Psychology teaches the art of sublimation, a process by which this energy [of the elemental emotions] can be liberated into constructive and appropriate channels" (45).

Freud's (35, p. 19) statement is that the "employment of the primitive energies for higher aims is known as sublimation." He goes on to remark that "the extent to which it occurs in normally educable children is really enormous" (*ibid.*). For many psychoanalysts, as Mursell (82, p. 79) has pointed out, sublimation is a possibility limited for the most part to early childhood; though others do not seem to recognize this limitation.

The technique of sublimation is treated especially by Barbara Low, as cited by Jelliffe (55, p. 466). Interesting applications of the doctrine are provided by Hall (39); W. R. Wells (124; 123—sublimation through religion); and, most entertaining, through application to choice of vocations, White (128; 126, p. 278).

Limitations appear however within the doctrine itself, as Mursell (82) has shown. Jelliffe (55, p. 462) observes that "very few people are capable of sublimation, since this would be absolute conformity to reality." Freud (34, pp. 33-34) maintains that sublimation is "only available to the few. It presupposes special gifts and dispositions" (cf. also 34, pp. 69-70). Cf. Eddy's (22, p. 45) application of the principle not as a "panacea for all," or "easy for many."

There is indeed a considerable group of students who recognize sublimation only in a more or less modified sense. Hocking (48, p. 200) says "every competitive interest must be so transformed or interpreted as to be non-competitive or an ingredient in a non-competitive interest." Dewey (20, p. 141) describes sublimation as making an impulse into a "contributory factor in some more inclusive and complex activity, in which it is reduced to a subordinate yet effective place." Bartlett's (4, pp. 96-97) view is similar. Tanney (115, p. 250) holds that a part of the psychic energy is inseparably attached to each of the various instincts. Jung's (56, p. 150) idea of sublimation is naturally a modified one, in view of his broader conception of "the *libido*." Moore's (79, p. 244) conception of sublimation as seeking "an outlet in . . . doing something of value to other beings" assumes "that we have as many impulses as we have forms of mental abilities," "and it cannot be

taboo on this "perversion" — a taboo which Moll remarks arises from social concern for normal relations between the sexes — receives a new clinical impress.²

said that any one of these is the sole driving force of human nature," Hart (44, pp. 600, 590), while maintaining that "the tendency toward the recognition of the fundamental identity and transmutability of all forms of emotional energy is becoming widely prevalent," acknowledges that "certain types of functioning become at times almost overwhelmingly imperative."

The whole conception of sublimation has been subjected to serious criticism, notably by Mursell (82), Woodworth (132, p. 191), Allport (3, p. 75), and Hamilton (42, p. 419).

²The social explanation of the taboo is given by Moll (78, pp. 194-195), also by Wile (130, p. 101). The generally accepted idea that masturbation drains vitality is stated in Hall (38, p. 464; 37, pp. 432-471, 501-502, where references on masturbation as an evil are cited); in Fielding (29, p. 122); and in the quotation from Sloan, in the preceding note. The practice is referred to as a "perversion" by Prince (93, p. 457); as a "neurosis or perversion" (though with lenience) by Fisher (40, p. 255); and as "pathological" by Menninger (75, p. 305). Hamilton (41; 42, p. 327) infers from his studies of monkeys that masturbation must be peculiar to abnormal conditions of life; an idea which appears in Elliott and Bone's (23, p. 78) book as the view that "habitual solitary sexual indulgence represents a turning away from reality, an attempt to compensate for what one cannot accomplish in the actual world." Tannenbaum (114, p. 101) lists masturbation with pollutions, etc., and dementia precox, as "most important pathological and psychological conditions" resulting from sexual abstinence.

Masturbation "is an infantile way of seeking sex gratification," according to J. W. F. Meagher, quoted by Eddy (22, p. 43). Psychoanalytic statements of this view, often with recognition of present causes, appear in F. L. Wells (121, index; 122, p. 93; 120, pp. 324-325); Kempl (58, pp. 150-151); Menninger (as cited in the preceding paragraph); Wickes (129, pp. 293-294); Menzies (76, pp. iv, 89-95); etc.

III

SOME RESULTS OF THE THEORY IN PRACTICE

If to the biologically minded physician or psychologist this view of sublimation seems absurd or unimportant, it should be observed that, besides holding theoretical interest, the view has practical consequences. It may have good results in encouraging idealistic efforts; but it has had effects upon many sincere individuals. Cases come to mind of unmarried persons whose struggle to sublimate is painfully continuous. Among college students the same struggle exacts an unmeasured toll of worry, nervousness, and in some instances ethical, mental, and physical collapse. For, in addition to their religious teachings, college men (at least until recently) have been beset with the Y. M. C. A. lecturer's dictum that "every drop of semen is worth twenty drops of the purest blood"; with the biology professor's pointed remark that "monkeys are given to masturbation"; and with the Good Fellow's counsel to the masturbator, faithfully reported in *Elmer Gantry*, to "run like hell."³

The precise amount of worry that occurs in college students over their "unsublimated sexuality" can only be guessed at. Perhaps it is much less within the last few years. The present study of college graduate and professional men provides no answer to this question. The study, however, has brought to light several more of those instances in which an amazing amount of worry, discouragement, and self-depreciation had been going on for years, and those the

³ Cf. similarly Hall, Moll, Fielding, and Menzies, in the preceding note.

years which should have been freest for development in men who outwardly seemed the embodiment of physical and mental health. One example is a young man who worried thus from his sixth to his thirtieth year with regard to his recurrent masturbation; a period during which his intellectual and physical development were excellent nevertheless. (At thirty, he happened to read a book by Robie condemning the taboo on masturbation. The worry stopped. His intellectual development continued.)

In another case the struggle began likewise at six years of age, and, to the astonishment of friends, culminated at the age of twenty-six in a nervous breakdown with somatic delusions. The worry was stopped short at that time, and the way quickly opened for a complete return to health by the following simple conversation. As the writer had been working in psychopathology and had noticed the increasing anxiety of our subject, he finally approached him, when particularly depressed, with the friendly remark: "Look here, young fellow, I am going to ask you some questions if you don't watch out." "Go ahead." "Well, you are in a state of 'conflict,' are you not?" "Yes." "Does it have to do with one of the 'instincts'?" "Yes" (with rising inflection each time). "The sex instinct, for instance?" "Yes!" "Well. When you were a kid, like most of the others, did you masturbate occasionally?" "Yes" (lowering inflection now). "And were you able to cut it out?" "No." "Is all that what you have been worrying about?" "That's it." "But I thought you said yesterday that when Dr. ——— (the college physician) asked you if anything was worrying you, you told him nothing was!" "That's right. I lied to him." "Read this book" (handing him one of the books by Robie or Long which aim to put the unmarried masturbator's mind at ease). He read the book; and the next day was heard whistling for the first time in weeks.⁴

Other cases of conflict on the same score include an excellent fellow who made no approaches to girls whatsoever, though definitely

⁴Cases of this sort are a commonplace with those who do mental hygiene work with young men. Cf. the contributions of Hall (40, pp. 132-133, 177-185); and Kerns (59, p. 694) (though the exact recommendations he gave his patients are not stated).

The book lent the subject cited here was probably Long (67) or Robie (98).

attracted by them, until he was twenty-three years old, because up to that time he had believed his practice of occasional masturbation made him unworthy of their company; several moral men who had finally started going to prostitutes as the lesser evil; a theological student, who might have been but was not included among the chosen forty, who studied in his room in his bathrobe so he could take a cold shower every hour or so; and a man who, as a college senior with a sound physique, had taken the college scientists literally, kept his time for rest at a minimum and his recreation at zero ("I have all that extra energy: why can't I use it?"), increased more and more his physical and mental activity while keeping up regular cold baths, and came down with pneumonia, from which he recovered only to continue the same struggle through four graduate years.

More extreme instances than these could be found, no doubt. Cases of suicide are not unknown.⁵ Cases of spiritual suicide are less striking, but they occur. The following example, not so extreme as it might be, is reported by a young leader in his field of scholarship. In his junior year in high school, he says, "the principal required all the boys in the class to go into the school auditorium to hear a talk by Homer Rodheaver, Billy Sunday's right-hand man. The talk pictured the horrible ills that came from sex indulgence, including masturbation: insanity, physical deterioration, etc. The emotion of fear was much appealed to. One of the members of the class, Tom . . . , grew pale and fainted away. He was terribly sensitive about it afterwards, and it was an important factor—how important I do not know—in his dropping out of school.

"Tom was fair, well-built, and noted for studious habits and an unusual flare for mechanics, especially electricity. He was quiet, but well liked. In his studies, he was always at or near the top of the class; and, had he continued, I really believe he would have made a mark in the world. As it was, some time after leaving the school he married, and has acquired the reputation of being very clever in an engineering job of some kind. He may well have taken one of the correspondence courses—he was the type who would, and who would be apt to get much out of it."

Thus the view of sublimation, as variously preached and received, affects the lives of a considerable number of persons. It should be noted that all the instances cited here are from the histories of very superior individuals, judging by their academic and later careers.

⁵Cf. Hall (37, Vol. I, p. 452).

IV

AIM AND METHOD OF THE PRESENT STUDY

The first purpose of the study was to find out whether "complete sublimation" occurs in healthy, active intellectual men in their twenties and thirties. It was plain at the outset that mere reference to historical bachelors established nothing, any more than do the preachments of devotees of the theory of sublimation prove anything. It was clear also that any selection of inferior persons, such as practitioners' neurotic patients, or inmates of a prison, would prove nothing; as, according to the theory, such people are not expected to be successful sublimators. A test of the theory would come only from a selection of physically, mentally, and morally superior persons. The present contribution claims statistical significance only in this selection of superior individuals.⁶

To find such persons, while avoiding publicity, in lieu of feasible experimental measures, the writer could only choose the cases and collect the data personally. His subjective impression of any candidate's fitness for this study he checked, however, by the objective facts of athletic activities, high intellectual attainments, happy participation in social relations with both sexes, aesthetic interests and accomplishments, and, for ethi-

⁶Previous relevant studies include the following, with the references they provide: Hall, Moll, J. W. F. Meagher, as per Note 2 *supra*; Menzies (76); Davis (16); and Stekel (112). Distinctly related also are Hamilton (43), and especially Peck and Wells (88).

cal development, the respect of the subject's fellows. Thus it will be noted that "rakes" were specifically excluded, along with morons, neurotics, and other abnormal personalities, so far as possible. On this basis a moral man with great capacity for physical and mental work, but with no evidence of aesthetic need or outlet, would have been excluded. Actually, no individual of such non-aesthetic reaction was met with. In similar fashion, a genius in physical, mental, and aesthetic lines but without concern for more than his narrowly egoistic wishes would not have been considered for the study; the few who seemed essentially egoistic were not sought out.

An exception to the foregoing care in selection may appear in the depressed and temporarily deluded young man whose case was cited above. This individual is included because his disorder was only temporary, it was clearly related to misinformation which the other subjects had fortunately missed or had found ways to counteract, and he himself was eminently normal in other respects and quickly became so in all respects. He is rated, indeed, as one of the very superior individuals.

Further apparent exceptions may be one or two subjects whose ratings in athletics, or in other particular respects, are not of the highest. Obviously, however, an individual who is superior in general is not necessarily very superior in every respect. As a matter of fact, the subjects rated low in athletics, for example, were included because of their unusual attainments in general for their ages, while at the same time they enjoyed excellent physical health. It must be remembered, too, that the scale employed here is a very high one; an individual low on this scale would rank high in an average college or professional group.

From these subjects the data, shortly to be presented, were obtained through non-clinical conversation; clinical subjects being excluded, with the single "captured" exception just mentioned. The approach was

an eminently natural one. Through personal acquaintance and companionship based on common interests (athletic, social, or intellectual), the conversation would turn some time to the writer's doctorate. When told the thesis was on "Belief and Behavior," the subject would naturally ask how that topic was being treated. This would bring out the point (about as follows) that one of the problems in the thesis was "whether there is anything in the current claim that religious beliefs serve as an outlet for sex emotion;" a problem which, if it could be solved, would have considerable psychological and sociological importance. "But for that matter," continuing, "the whole question of 'sublimation' is a critical one. We need to know whether the several normal urges in a human being are capable of this sort of transmutation.

"The principal difficulty here is the lack of data on normal subjects. We have only a few legends about the sexlessness of religious persons, and about Sir Isaac Newton, for example, whom some suppose to have converted every bit of sex energy into intellectual productivity. We have, too, the observations on monkeys, neurotics, and the insane, who, instead of sublimating, are given to such direct outlets as masturbation. But, for all we know, this same phenomenon may be found in normal persons: so far from proving that normal persons must sublimate, the observations of the monkeys and the rest prove nothing about it. In fact, to argue that, because abnormal and inferior individuals masturbate to excess, masturbation is abnormal, is

¹Cf. W. R. Wells (123).

like arguing that, because abnormal persons eat to excess, eating is abnormal. We know that masturbation is common in adolescents; and lately some physicians have asserted that this same adjustment is common in normal, unmarried adults. But since the cases cited by these doctors *may* have been a selected lot (as sufferers from other ailments they may have been in some general way inferior), and since the theory of complete sublimation is supposed to operate best in persons of the highest type, data are needed on just these people. If they really do sublimate, then sublimation must be something real."

"Do you think it is real?" would be the natural inquiry.

"Well, frankly, I doubt the whole theory. I doubt it upon both theoretical and empirical grounds." The theory of sublimation does violence to a number of our conceptions of the organism; and, empirically, I have not found much evidence, among men at least, for the truth of the theory. As a matter of fact, I have started a count of superior, single men, those whose ethical outlook would encourage sublimation, to see whether it works in them. The most interesting result so far is that I have not found a single man who pretends to sublimate completely."

"Well! What *do* you find?"

(At one point in the investigation :) "Every man on my list so far masturbates." "Really? But are they normal men?" "I think they are normal and super-

*The doubt was thus expressed to free the subject, not to prejudice either him or the investigator, for facts.

ior." "What do you mean by 'superior'?" "This would be explained briefly—"men like yourself, in short." "But how many do you have on your list?" "As yet, I have only a few. But I am going to get more." "How are you going to get them?" "I'll just tell them about what I'm working on, and give them a chance to contribute; provided, of course, that they belong to the class of subjects I want."

"Did you say I belonged in that class?" "Yes, in my opinion you do. If you'd like to contribute, I would enter your data with the others." "I don't care. What do you want to know?" "The data would then be obtained and recorded within about three minutes, as a rule."

Certain sources of fallacy appear in this method of gathering data. A major source is that the writer had to select the subjects himself, without check by any one else. This condition, however, seemed unavoidable. Another great source of error would appear in the various opportunities which were allowed for the subject to escape from the questioning. But these opportunities were supplied deliberately, partly out of courtesy to the subjects who were thus approached, and partly to insure an easy attitude toward the investigation, an attitude which would conduce to the desired frankness. In point of fact, not one individual chose to change the topic of conversation: every subject selected for this research contributed to it.

The question then remains, How true were the contributions? Without attempting to justify questionnaires or interviews in general, the writer feels that

the data presented here include a significant test of their own validity, namely, an internal test. The emphasis on masturbation, noted in the interview, was made, because to assume this most unapproved outlet for sex tension would disarm the individual at once, and he could be trusted to report on other items with ease. That the subjects did respond very fully indeed will be clear from the results presented below.⁹

To make the case surer, however, a follow-up was effected by mail, some five years after the collection of the original data, on every man who had professed that "dreams" (nocturnal emissions) were his only sexual outlet. As the form of this follow-up letter may have been important, and as its text shows significant stages of the study, it is quoted here:

"Dear _____:

"(This letter is personal, and typed personally by its writer, W. S. Taylor, sometime of _____, _____, [addresses that would be remembered by the reader], etc., and now a professor of psychology. *Please return the entire letter.*)

"You may remember that when we were _____ [a reminder of circumstances again] you contributed data toward a small study I was making 'on the side.' This study was a criticism or test of the current theory of 'sublimation,' a theory which supposes that sex energy can be transmuted into intellectual, artistic, and other 'higher channels.' As according to the theory such sublimation is possible only for superior human beings, and as our knowledge of the sexuality of normal superior human beings is sadly deficient anyway, my test was to choose a sampling of very superior single men, explaining the problem to them, and to get from each a record of his own sex adjustments. You were one of those men.

"This is to report (a) that your contribution was not lost, (b) to indicate to you my results to date, and (c) to ask for a little further

⁹Peck and Wells reason somewhat similarly in their study (88, pp. 702-703).

data. My plan is to publish the material in a technical monograph. In form, the monograph will include tables of data, of course without any possibility of identification as individuals, as a group, or as representatives of a university (since my subjects are reported truthfully as having been chosen from several leading universities over a period of six years); and there will be considerable theoretical discussion included. The substance of the theoretical discussion has already been brought to the attention of psychologists, as I read it as an eight-minute paper at the International Congress of Psychology which met at Yale University last September. (I avoided all publicity then by the simple device of having no abstract available beforehand for reporters to use—abstracts being the official basis for all reporting; and by reading the material then at the meeting as a purely theoretical discussion which was so technical that no reporter seemed interested. Naturally my purpose in this piece of work, as in previous publications on other topics, is scientific contribution, not publicity.)

"In brief, I have now listed 40 superior single men. Every one that I asked contributed data as you did—a significant though not a final point of statistical merit. Of these 40, 22½% indicated that, as specifically sexual outlet, they 'got along' on nocturnal emissions ('wet dreams,' which I shall symbolize by 'D') alone; 15% had their outlet through 'spooning' or 'petting' to the point of orgasm, orgasm either at the time or following dependably in a dream (an outlet I call 'S'); 57½% stated that they masturbated from time to time ('M'); 7% resorted to prostitutes occasionally ('P'); and 13% had relations with women ('W') other than common prostitutes. (The totals are more than 100% because several subjects had more than one form of outlet.) In other words, every one of these men had some form of sex outlet, not one 'sublimated' away his physical sexuality completely; and, of the lot, only one in four or five limited his overt sexual expressions to sleeping dreams ('D'). [Note: This follow-up reduced this ratio markedly; as will appear.]

"An interesting point here is that of the comparatively few subjects who reported 'D' (dreams) alone, all but two were under 25 years of age (thirty-five of all the subjects were over 25 years old). This made me think that perhaps 'Nature demands her rights,' will not be put off so easily, after the age of 25. I thought this especially when I noticed that of the two exceptions above 25, one had had much commerce with prostitutes some years before; which suggested

that that *memory-pattern* of actual intercourse might have helped him 'dream' more easily and successfully now. To put it another way, only two of the thirty-five men who were aged more than 25 were reported as 'D's', whereas eight of the fifteen subjects under 25 were 'D's'! [Only now in copying this document for publication (for which it was not planned) does the writer realize the glaring mistakes in this paragraph. The facts were that of the ten subjects who reported "D" only, all but two were under 26 years of age; while *twenty-five* men, including the other two 'D's', were over 25 years old. Still, the replies showed no evidence of distortion by these errors in the letter.--Continuing:]

"Why this significant age difference? My only hypothesis was, as already suggested, some greater elasticity and adaptability of the men under 25;--until I began to check up with the other one of the two exceptions mentioned. I interviewed this man again, explained my special question to him, and showed him my table of data (without names) in a frank way. I say *frank*, because for each of these two 'D's' among the older men I had a special entry: For the other man, a reference to his former 'P's'; and for this man, a note which read: 'An attitude of cultivated reserve which appeared in this interview, before the 'D' was learned, made this the case in which the writer felt most doubtful of getting the truth.' I explained that he may well have thought my original inquiry was not serious, or ought not to be taken seriously; so that my record of his case might not be correct. Yet, I explained, it may be that with few exceptions age had something to do with the form of sex adjustment, and that he was one of the exceptions.

"I have another theory," was his remark. "What is it?" I asked. "It is that men get more objective after the age of 25." "What do you mean?" "I mean," he said, "that although I was over 25 when you first asked me about this subject, I was not nearly so objective then as I am now; and I suspect that you might find the same thing with a lot of these younger men. The fact is, I did not realize, as you say, that your investigation was serious; or, if I did, I did not appreciate its importance. If I had, I might have told you then, as I do not mind telling you now, that my adjustment when you first asked me was "M'" (i.e., masturbation--which left me with only one 'D' above the age of 25).

"Of course this friendly suggestion and revised report set me thinking. To you now I turn in the same way: I can understand

perfectly that my approach for data in the first place may have been so casual as to make you think it only proper to turn it aside as gracefully as possible. But whether you did or not, whether or not your record as I have it of that time (which is 'D') is fully accurate, you can understand now that those 'D's' on my list are just the entries that will be most doubted by the psychologists who read my report; thus you will appreciate the fact that a check on the data now will make my contribution much more valid, while expressing my confidence in your friendly cooperation in that I thus come to you again.

"Would you answer, in the spaces provided, these questions: (The forms of overt sex expression which I have listed are, again, D—nocturnal emissions or 'wet dreams'; S—spooning or 'necking' so 'heavy' that an orgasm or complete emission comes about in sleep soon after if not at the time; M—masturbation, any form of mechanical self-stimulation which culminates in orgasm; P—prostitutes; and W—sexual intercourse with one or more women other than mere prostitutes.)

"(1) Please write here those symbols for all the forms of such outlet which you employed at the period we first talked about this problem.

"(2) If 'D' was your only adjustment then, then (unproper of my standing exceptional case mentioned above—though you were younger of course) had you *ever* had intercourse or orgasm otherwise brought on in intimate physical contact with another human being?

"(3) If 'D' was your only adjustment then, again, had you *ever* masturbated, as during adolescence, so far as you remember?

"Then as a test of the guess that age perhaps helps determine the form of sex outlet,

"(4) please list here any different forms of outlet you have taken up since our first interview (S, M, P, or W; different, that is, from what you have listed under (1), above); and

"(5) please enter here the age at which each of the adjustments written under the preceding question began with you (just your nearest birthday for each).

"---The foregoing completes the most needed data. If, however, in the space below or on another sheet you wish to enter any comments about 'D' as a possible adjustment, 'M' as an adjustment, early marriage, or anything else, such comments would be appreciated also. (See foot of this page in any event, please).

[Considerable space]

"N. B.1 In order to be sure every subject has been checked off, I must ask for your signature on the line below; with the understanding that no other person will see it, and that it will be destroyed upon entering the data by myself only:

[Written in:] Unnecessary! Your name is on first sheet.

"THANKS; but in any case please be SURE TO RETURN ALL THREE of these sheets whether or not you add anything to them.

"And Best New Year's Greetings from W. S. Taylor."

Every man thus addressed replied; although a few individuals, who later explained they had been busy only, required reminders. Apparently, too, all the replies were fully frank.

No follow-up was made of the other men, the majority who had reported other outlets than dreams, because no attitude conducive to *overstatement* had appeared in the original interviews.

The cooperation which the chosen subjects gave, and their continuance of friendly associations afterwards, are a tribute to the objectivity of these men; also perhaps something of a tribute to our graduate system.

V

THE FINDINGS

The data which follow were given by 40 men, then unmarried, in the years 1919-1924; with some corrections, as indicated above, in 1929-1930. All of these men stood very high, in a number of instances at the top, in graduate and professional schools of several leading American universities. Their athletic activities then included boxing, wrestling, swimming, tennis, hand-ball, golf, and mountain climbing. A considerable number had been on college athletic teams. Socially, they seemed very normal. Aesthetically, they enjoyed, and many of them produced amateurishly, various forms of art. Ethically, they were apparently of the sort that would hold the respect of professional associates.

The ages of these subjects, listed in Table 1, below, ranged from 21 to 38 years, with the median between 26 and 27, and the mean at slightly less than 27. Their fields of professional study or practice were as shown in Table 3.

The number of cases is, of course, small; but the group as a whole is believed to have significance, selected as it is, in that some overt expression of physical sexuality occurs in every individual on the list: dreams (with nocturnal emissions) in a few, and more conscious outlets in most.

The sex adjustments appear in the tables, by individual ages - nearest birthdays (Table 1); by age groups (Table 2); by professional interest groups (Table 3);

and by rating groups—groups made up according to the investigator's ratings of the individuals' intellectual, athletic, aesthetic, and social powers (Table 4.) In a further table, the 40 individuals are classified according to their sex adjustments, to allow for any significant comparisons between these "adjustment groups" (Table 5).

In the tables, the abbreviations and symbols have the following meanings:

NATIONALITIES

Am.—American white

For.—Foreign white, not Jewish

J.—Jewish

RATINGS

3—Excellent

2—Very good

1—Good

0—Fair

SEX ADJUSTMENTS

- D*— Nocturnal emissions, usually or always accompanied by dreams, reported as the only adjustment. It should be remarked that many, perhaps all, of the subjects who depended largely upon the other adjustments in this list had these "dreams" occasionally too; but, in order to reserve the "D" as a mark for those subjects who took no other outlet, the merely intercurrent "dreams" of other subjects are not entered in the tables.
- S*— "Spooning," "necking," or "petting," rather regularly, to the extent of orgasm at the time or during the subsequent night's sleep.
- M*— Masturbation, at more or less regular intervals; understood in the sense defined by Hamilton: "By masturbation I mean conscious and deliberate self-stimulation of the genitals for the purpose of obtaining thereby sexual

gratification of some sort or other. I do not classify as masturbation such practises as biting the nails, chewing gum, reading the Bible for its erotic interest, indulging in sex fantasies, pressing one's genitals against the body of another person in love-making, driving automobiles at a furious speed, or making high dives." (Quoted, in view of current psychoanalytic confusion, from Hamilton, 43, p. 424.)

P--- Prostitutes resorted to upon occasion.

H--- Fairly regular intercourse with one or more women other than prostitutes.

-- -- This sign in place of a letter means that that adjustment has been replaced latterly by the one or more given letters. No effort was made to obtain a complete record of past adjustments, however; and in the counts, the reported "-s" are disregarded to provided statistics of the adjustments at the time.

PROFESSIONAL INTERESTS

(These groupings are somewhat informal, to characterize the actual interests, as contrasted with the professional labels, of these men individually without revealing their personal identities.)

Exact Science---Chemistry, physics, mathematics, certain types of psychology, and, in view of the attitude and method of the individuals occupied with it here, medicine.

Human Science---Psychology for the most part; also, considering the point of view of their representatives, education, philosophy, and certain types of theology.

Social Studies---History, government, law, economics, commerce, and some theology; considered from the outlook of the individuals represented.

Literature---Ancient, modern, English, and foreign.

Apart from showing the falsity of a number of current generalizations about the various sex adjustments, the detailed calculations in the tables are of course of no great statistical significance; the cases are few, and the ratings are more or less subjective. The falsity of those generalizations, however, will be developed fur-

TABLE I
INDIVIDUALS BY AGES

Individuals		Ratings				Sex adjustments			
Ages	Nationalities	Intellectual	Athletic	Aesthetic	Social	Sums	D	S	M P W (Case)
21	Am.	5	2	5	3	11		M	(1)
22	Am.	5	2	2	1	8	D	—	(2)
22	Am.	3	3	3	3	12	D		(3)
22	Am.	2	3	2	3	10		S	(4)
23	Am.	5	3	3	3	12	D		(5)
23	J.	5	0	2	1	6	D		(6)
23	Am.	3	2	3	3	11		S	(7)
24	Am.	5	3	2	3	11		M	(8)
24	Am.	5	2	2	2	9		M	(9)
24	Am.	3	2	2	3	10		M	(10)
25	Am.	3	2	2	3	10	D		(11)
25	Am.	3	3	3	3	12		M	(12)
25	Am.	5	1	1	1	6	D		(13)
25	Am.	3	3	3	3	12		M	(14)
25	Am.	5	3	2	3	10		W	(15)
26	Am.	3	3	3	3	12		S	(16)
26	Am.	5	3	3	3	12			(17)
26	Am.	5	1	2	3	10		M	(18)
26	Am.	5	2	2	3	11		M	(19)
26	Am.	5	3	2	3	11		M	(20)

Table 1 (continued)
INDIVIDUALS BY AGES

Individuals		Ratings				Sex adjustments				
Ages	Nationalities	Intellectual	Athletic	Aesthetic	Social	Sum	D	S	M	P W (Case)
27	J.	3	2	3	3	10	D			— (21)
27	Am.	3	3	3	2	11	—		M	(22)
27	For.	3	3	3	3	12			M	(23)
27	Am.	3	2	2	3	10		S	M	(24)
27	Am.	3	1	2	1	7			M	(25)
27	Am.	3	3	3	3	12			M	(26)
28	Am.	3	2	2	2	9			M	(27)
28	Am.	3	2	2	2	10			M	(28)
28	For.	3	3	3	2	11			M	(29)
28	Am.	3	2	2	2	9			M	(30)
29	Am.	3	2	3	3	11		S	M	(31)
29	Am.	3	3	3	3	12			M	(32)
29	Am.	3	1	2	2	8			M	(33)
30	Am.	3	1	1	1	7			M	(34)
30	For.	3	2	3	3	11		S	W	(35)
32	Am.	3	2	2	2	10			W	(36)
32	For.	3	2	2	2	9		S	—	(37)
33	Am.	3	1	2	1	8			M	(38)
33	Am.	3	3	3	3	12			M	(39)
33	Am.	3	2	3	3	11			W	(40)
Percentages reporting each adjustment:						18	15	65	S	15

ther in the discussion which follows. We should note, too, that, independently of the smaller calculations, the tables bring out a number of positive points and suggestions, especially in the light of further data which will be added in the following pages.

Table 1, which presents all the cases individually, shows an unsublimated quantum of sex expression for every subject. Within the sex adjustments, too, a distinct trend to the right is noticeable as the ages increase: there are more D's among the younger subjects, and more W's among the older ones. This trend is much more obvious in Table 2, where cases are grouped by ages. Here 40% of the men aged 21-25 are in the D column, while only 5% of the 26-30 group, and 0% of the oldest group (32-38) are in that column.

Table 3, which is made up of professional interest groups, fails to show any significant relation between type of professional interest and type of sex outlet, for these few cases at least.

In Table 4, classification by ratings, the contrast between the findings of the present study and conventional expectations is perhaps most apparent. The lowest general group (according to the ratings), namely, Sums 6-8, instead of having the largest amount of masturbatory expression, has the smallest amount; and the highest group, instead of reporting the largest percentage of D's (usually regarded as the most "sublimational" of all "direct" outlets), reports only 10% D's, which contrasts sharply with the 43% D's reported by the lowest group, mentioned first. The athletic ratings make no better case for sublimation:

TABLE 2
AGE GROUPS

Ages	Cases	Intellectual	Average ratings		Sums	D	S	Sex adjustments			Totals
			Athletic	Aesthetic				M	F	W	
21-25	15	2.9	2.2	2.3	10.0	40	13	47	7	7	114%
26-30	20	3.0	2.2	2.6	10.3	5	15	75	10	15	120%
32-38	5	3.0	2.0	2.6	11.0	0	20	60	0	20	100%

TABLE 3
PROFESSIONAL INTEREST GROUPS

Professional Interests	Cases	Age range	Av. age	Average ratings			Sums	D	S	M	F	W	Totals
				Intel.	Ath.	Aes.							
Exact Sci.	10	24-29	26	3.0	2.2	2.2	9.7	10	10	70	20	0	100%
Human Sci.	14	21-33	27	3.0	2.2	2.5	10.4	21	14	57	7	14	114%
Social Stud.	10	22-34	26	2.9	2.1	2.6	9.9	30	20	50	0	20	120%
Literature	6	26-38	29	3.0	2.2	2.8	10.8	0	17	83	0	17	117%

the D's *decrease* as the athletic ratings *increase*; although here as elsewhere we must remember that the principal significance of these findings is negative rather than positive—destructive rather than constructive of generalizations. The same general trend appears, as it happens, in the aesthetic and social ratings. It would be most interesting to see this point tested on a larger number of subjects. Yet the fact should not be overlooked that the data provide no evidence that D connotes personal inferiority either: the D list includes as fine specimens of young manhood as there are in the entire group.

Table 5 compares the sex adjustments themselves with respect to the individuals grouped under them. Here we find that the group with the lowest general rating (Sum 8.3) is the P group; the next lowest is the

TABLE 4
RATING GROUPS

Rating sums	Cases	Age range	Av. age	Sex adjustments					Totals
				D	S	M	P	W	
6-8	7	22-33	27	43	0	43	29	0	115%
9-10	13	22-33	27	15	23	54	8	13	115%
11-12	20	21-38	27	10	15	75	0	10	110%
Athletic ratings									
0	1	23	23	100	0	0	0	0	100%
1	6	25-33	28	17	0	67	13	0	117%
2	13	21-38	27	17	7	56	6	22	138%
3	15	22-34	26	13	20	73	0	0	106%
Aesthetic ratings									
1	1	25	25	100	0	0	0	0	100%
2	13	22-33	26	22	17	50	17	11	117%
3	21	21-38	27	10	14	81	0	5	110%
Social ratings									
1	6	22-33	27	50	0	50	17	0	117%
2	8	24-33	28	0	0	75	12	13	100%
3	26	21-38	27	15	23	62	4	12	116%

TABLE 5
SEX-ADJUSTMENT GROUPS

Adjustment	Cases	Age range	Av. age	Average ratings				
				Intel.	Ath.	Aes.	Soc.	Sums
D (only)	7	22-27	24	3.0	1.9	2.1	2.1	9.1
S (all)	6	22-32	27	2.8	2.5	2.5	3.0	10.8
M (all)	25	21-34	27	3.0	2.3	2.6	2.5	10.4
P (all)	3	24-29	27	3.0	1.3	2.0	2.0	8.3
W (all)	5	25-38	30	3.0	2.2	2.6	2.8	10.6

D group; and then come the M, W, and S groups about on one level (10.4, 10.6, and 10.8).

Such are the findings in this group of men. Considering the fact of sex outlet in every case, an important question may be raised: Can this be a group of superior men? Is not the existence of celibate men in religious orders an obvious challenge to the findings given here?

In answer to this question, the investigator will include some information which he has received from an unusual source, a scientist, now married, who a few years ago was a *Roman Catholic priest*. This man's testimony gains weight from the facts that his religion was very vital to him, and that he bears no malice toward it now.

During his priesthood, for a considerable period in one community he received the required confessions of more than 300 monks and priests. He estimates that about 80% of the men confessed looking at those portions of female parishioners' bodies which the church forbids them to consider; about the same percentage confessed lascivious fantasies (most commonly about women); possibly 20% confessed "impure sensations" they had when hearing or reading about the tortures

of the martyrs—a counterpart for his observation that a few of the monks beat themselves very loudly at their weekly castigations (points which did not come up in any of our 40 subjects); and a few felt that they should confess pleasure at overhearing flattering remarks about their persons, receiving love letters, and even being followed on the street by unstable women admirers.

Doubtless related to those ideational processes, and directly relevant to our study, are this informant's impressions of the men's actual sex outlets. He remembers that it was very common indeed for these celibates to confess that they had allowed themselves to assume a posture in sleeping, or in half-sleep, which would stimulate a "pollution." This most common adjustment, however, was probably omitted from the confessions of many, because it is so close to the purely involuntary emissions which the church regards as natural and without sin. A much smaller percentage had to confess waking masturbation. Only in rare instances was intercourse known to occur; and in those instances, barring an occasional case of secret persistence in concubinage, the individuals almost invariably gave up their orders.¹⁰

¹⁰For the sexual struggles of earlier ascetics, see May (73*a*, pp. 51 ff., 124 ff., 131-132), also Lecky (63*a*, Vol. 2, pp. 118-119). The same problems arose in chivalry (73*a*, pp. 118 ff.).

VI

THE SEVERAL ADJUSTMENTS

The particular forms of sex outlet listed for our 40 subjects are not without theoretical and practical interest on their own account.

First with regard to D ("dreams"): No effort was made to find out just how much consciousness of sexuality went with these nocturnal emissions. The investigator's impression is, however, that most, if not all, of the "dreams" were accompanied by sex imagery. Certainly some sex emotion was usual in them, although, as Hall (38, Vol. I, p. 466) remarked, "no personal sex experience is necessary to awaken these dreams." Several of the men remarked that they brought on their "dreams" deliberately, as a means of relief from increasing restlessness. Some did this by "spooning," as already mentioned; but their cases are considered under that caption, farther on. One, as often as he felt the need, went to a dance, with the invariable result that an emission occurred during his sleep afterwards. (This may be related to the S group, but also to the principle of relaxation, of which something more will be said. This case may also be related to the fantasy factor, as follows, though perhaps through sleeping dreams only.) One subject, finding that "every week or so" he woke up before dawn sleepless with sex pressure, hit upon the plan of voluntarily fantasizing upon erotic relations with his sweetheart (who "would never 'spoon'"), after which he would doze off soothed, and have his "dream" before morn-

ing. Still others, judging by the group of celibate men reported at the end of the preceding section, very probably encouraged their "dreams" by more or less unconsciously exerted physical pressure, if only from the weight of the body.

(Peck and Wells report that suggestive fiction and shows are said to aggravate the problem. One wonders whether, in the light of the foregoing observations, the protocols obtained by these investigators were not perhaps more conventional than introspective on this point; or whether their subjects did not confuse the occurrence of a "dream" with an increase of "the problem.")¹¹

A perhaps important observation was made by another subject. He noticed that a needed "dream"

¹¹Peck and Wells (88, p. 712).

The question of the relation of fantasy-as-such to sex relief is a significant one, not without interest for the theory of sublimation. At least two of the writer's subjects remarked that continued indulgence in sex fantasy, whether by day or by night, and *whether or not an orgasm followed*, was felt as a distinct relief, so that the subject could work for another week or so very much as though he had had an orgasm. The only difference seemed to be that the fantasy took more time! The writer has difficulty harmonizing these observations with the other reports given here, especially because the men did not seem different in any essential way from the other subjects (they were both in the M group), and were at least as successful in all their interests, from athletics to love-making, as the average of the others. The explanation may be found possibly in a continued seminal seepage associated with such fantasizing, and in similar unostentatious but actual involvement of allied functions. As Curti (14, p. 318) puts it with regard to fantasy in general, "there seems to be little question that in dancing, erotic daydreaming, and other types of 'emotional outlet,' partial sex responses occur, chiefly internal and visceral. Such responses serve to change the physiological condition, thus altering the motivating stimulus and in some cases inducing relaxation."

was much more likely to occur if, instead of trying to work and play intensively all the time, he relaxed his attention for a few hours, and (quite non-sexually) "talked, read magazines, went to a 'movie,' or just loafed around." When questioned, he reported simply that the period of relaxation seemed to ease the general tension, whether or not it was sex tension; he "could feel it going." Often, indeed, he was quite surprised at the subsequent "dream," which was definitely sexual in emotion and imagery; surprised, because "he hadn't known he needed one," and in fact "hadn't been thinking anything about it!" The importance of this observation may lie partly in the fact that the subjects before us were *not* gentlemen of leisure, as anyone familiar with graduate and professional work in the better institutions knows; and, furthermore, most or all of these subjects had been taught that leisure is *just the wrong way to deal with the sex problem*. The present observation would seem especially worth checking up on other subjects. Theoretically, however, the point seems not necessarily within the scope of the present study.

The surprising shortage of D's after the 25th year, in Tables 1 and 2, has already been remarked. A glance at Table 1 shows that only one of the 25 subjects who had passed that age reported finally that D was his only outlet (Case 21); although three of the younger D's are now known to have maintained this adjustment until about 26, when they married, and a fourth, until in his 30's, when he married. The remaining two D's are accounted for by the report that

one married at 25, and one, before he reached that age, shifted to M, which he continued until his marriage at about 26.

Until the check-up which revealed the one D that persisted into the 30's, the investigator had indubitable record of only two men who maintained the D adjustment for any considerable time after 25. One of these was Case 21, already remarked; and that one had had much sex experience (P) in earlier years. The other man was not included in this study, for a number of reasons, one being that he came considerably out of the chronological period (which was 1919-1924). He "only had 'dreams'" until he was 30; "but," he says, "it was hell."

Subsequent comments by some of our D's are interesting.

Case 13 replies to the follow-up letter as follows: "I am a real D. I was, at least, up to the age of 26. I have always considered this rather unusual, for by the age of 18 or 19 I was fully aware of the near universality of M if not P. My explanation lies in a very unusual occurrence somewhere about the age of five. At that time my mother told me of a boy who was a persistent and abnormally frequent masturbator, whose habit resulted in feeble-mindedness. The story went on to tell that the boy finally had to be sent away to an institution for mental diseases, and as he left his home, his mother stooped or knelt to kiss him good-bye, and he picked up a pair of sharp shears and stabbed her in the temple with such force that she died. This story made an unusually strong impression on me, as my memory for it indicates. It was doubtless told to serve as a horrible example, and it worked perfectly. I kept my hands strictly away from my genitalia, although all I knew was that the boy had 'played with his penis,' not knowing that there was such a thing as orgasm for many years afterwards. In adolescence I rather accidentally escaped those exhibitionist parties at the swimming hole which I know occurred. In early manhood I had fairly frequent nocturnal

emissions, and did not know how to masturbate, and never felt sufficient urgency to invent a method." After marriage, however, during a period of absence from his wife, as he says, "I easily invented masturbation, and practiced it at first only when urgency was so great as to prevent sleep. I became convinced of the innocuousness of the practice under the influence of Robie's books, though I still feel that it is far from aesthetic. . . . In periods of separation from my wife I practice masturbation with some frequency, somewhat less, probably, than intercourse occurs usually. I find no sublimation whatever occurs during these periods of separation, though perhaps I can be said to be 'conditioned' to fairly frequent orgasms. I could get along on D now, but I no longer feel any moral necessity for restricting myself from M, and it is a lot more convenient than rolling around on a solitary bed in distress."

Case 2, in answer to the follow-up query as to whether he had ever had an orgasm in intimate contact with another person prior to reporting D, replies: "Yes! In what was my first 'petting' experience! And of course I was very much surprised." To the question about masturbation his reply is: "I did masturbate when young, but quit in what seems to me a very unusual way—and determinedly [not explained further] at age 16. I did not begin again until 23, three years before marriage—three of my hardest years. . . . I guess, though, I did have an easier time than many, sexually. I can give testimony to the effect that *much* can be done through sublimation. A deep interest in. . . [a theoretical subject] and in . . . [a practical subject] did wonders for me."

Case 11 made no comment as to the satisfactoriness of his adjustment. He says, however: "My only suspicion would be that you are carrying on your research with too strong a predilection for the view that it will prove that there are no cases of sublimation. . . . I am afraid of the testimony of subjects who know what your theory is."

Case 6 replies, to the question as to whether he had ever masturbated: "Yes, at very beginning, but soon on very rare occasions, because I had read of alleged injurious consequences." To the request to list any different forms of outlet taken up since the interview, he replies: "Married shortly thereafter; no extra-marital experiences whatsoever."

Case 5 writes: "I believe I always feared masturbation after being told stories about it when young. Also I believe I am not highly

sexed, that is, the sexual tension has never been really unpleasant. I have very distinct rhythms in my mood for work and sexual outlet doesn't seem to have any great effect on the mood. Sex tension has not bothered me much except when it prevents, or I think it prevents, me from working. This has never occurred very frequently." He is, however, a man of steady general enthusiasm for all his activities; perhaps an impressive case in behalf of the view of sex control through sublimation.

Case 3 is even more impressive evidence for that view. Here is a man as vigorous, balanced, and altogether delightful, as any on the list. He writes: "Until my marriage [at more than thirty years of age] I had had no form of 'adjustment' except D (except M once at about 14 years of age); nor did I feel that I was making any great effort to restrain myself. My D's, as I remember them, have been rather infrequent and particularly so since I have been most active in my work. During my college period they may have averaged two or three a month. I don't believe they have averaged one a month since. During my life so far, however, I have been quite active: working on forms of high-pressure jobs which leave me rather tired in the evening. I have usually been busy at something (certainly not *work* all the time!). Moreover, I have not associated much with the type of man who is known to go in for such [other] forms of outlet."

Of course several factors of possible explanation for the decrease of D's among the older men come to mind. These men have been subjected to temptation in its various forms over a longer period of time; and they have had more opportunity to revise their childhood ideas of good and bad. Whether there is an added, physical, factor, remains to be tested on more subjects—if it is possible to eliminate, sufficiently, the cultural and other complicating factors.

Turning to S (the adjustment of those who were given to erotic fondling with girls), we recognize a phenomenon well-known today. The use of this practice as a means to orgasmic relief, however, does not

seem to have been appreciated in the literature. In some cases, as remarked, the spooning served merely to touch off a "dream" in the subject's sleep the same night; in a number of cases it was indulged in to the point of orgasm at the time; and with at least two subjects it went as far as mutual masturbation with girls (listed in the tables under S, however, because not solitary). One case of the type which fondled to the point of orgasm may suffice.

This man said: "Yes, I'll tell you what my adjustment is if you won't think too badly of me. I'm ashamed of it, but it may interest you. I am engaged to be married, as you know; and, incidently, I write to my fiancée every day, and every letter I get from her thrills me much as her physical presence does. She is more attractive to me than anyone else is; and once she offered herself to me for intercourse, but I thought it would be safer to wait until we were married. I have never had relations with anyone else, and I never hope to.

"But, she is a long way off, and I only see her once or twice a year. So here is the part I am ashamed of. At the house where I live there is a minister's daughter who has a room not far from mine. Every few days when I am in my room with my door open she tip-toes in and throws herself into my arms and hangs upon my lips until we both have an orgasm. Then she goes out again and I scarcely see her until the next time.

"She knows I'm engaged, and she has no intention of cutting me out--she couldn't if she wanted to.--But that's the way it is."

The man is now married to his intended, and evidently happily. Whether the other girl ever gives him a thought has not been ascertained.

Certain practical questions suggest themselves. Is it true, as a maiden lady remarked to the writer one time, that the current practice of "spooning and petting is what drives young men to those awful houses?"¹² Or is it true rather that the indulgence in this practice

¹²Peck and Wells' (88) study would seem to support this view

"solves the problem" for many individuals as it seems to have done for the few subjects listed here? Or is there danger that the petting custom sets bad habits for some, habits which interfere with normal adjustments in marriage as Elliott and Bone (23, p. 69) suggest? Again, is it possible that any "cheapening of love" that occurs through spooning is in any measure offset by the preservation of erotic interest in heterosexuality? In other words, in this day of delay between physical maturity and marriage, a period during which a number of young people develop into homosexuals, is there virtue in the "petting" custom as a preservative of erotic normalcy? The writer has not sufficient data to answer these questions; but he thinks they deserve to be asked.

The adjustment which would seem to require more comment than any other is M (masturbation). The investigator was much surprised to find 63% of all the cases, and 72% of those above 25 years of age, reporting this adjustment. A prominent psychologist who knew the type of men chosen for the study was astonished at this finding. "I thought that was a phenomenon of adolescence!" he exclaimed. (This was exactly the attitude of the physician to whom the unhappy "liar" cited above—page 14—finally confided. "It's a kid trick; cut it out," the physician had said.) We should expect that nearly all of these men did masturbate during adolescence; though how many was not learned. It is certain, however, that at least one or two never masturbated until later.

The question arises at once, Why did they? The

fact of periodic tensions in the sexual apparatus of the male has long been recognized;¹³ but, as developed at the outset of the present study, an accepted view has been that anything more than "dreams" is unnecessary for the normal youth; and that masturbation, if not actually pathological, is the result at any rate of failure "to achieve adequate indirect expression." Elliott and Bone (23, pp. 7, 74, 80) infer (from Seabury, apparently) that in youths "there is resort to the direct outlet of masturbation" only because of "the natural indirect outlets being denied"; and that hence "in a perfectly ordered society, . . . the present extensive indulgence in the practise may disappear."

We have cited subjects, among the D's, above, that would seem to substantiate this position. On the other hand, there are cases which raise a doubt. Several of the subjects listed in Table I complained that despite all their activities they had to masturbate or have intercourse every so often in order to be able to work.

One subject, unusually competent, and in the writer's opinion eminently normal, had nocturnal emissions from the age of 7 (sic) to 21, when he changed deliberately to M, which continued to his marriage. His reasons for this change are not given.

Another very superior individual, after entering college, reflected that everything he had been taught before was wrong. Thinking then on the naturalness of the sex impulse, its evident periodicity and interference with his studies, and the fact that probably all of his ancestors for generations had been married before they were his age, upon his own initiative he tried masturbation, found that it solved the problem considerably, and continued to masturbate quite regularly until his marriage.

Another man had refrained from any explicit outlet other than

¹³Hall (38, Vol. 1, pp. 466); Hamilton (43, p. 119); Elliott and Bone (23, p. 7); etc.

"dreams" until he was 25. The struggle, however, had been constant, despite a very active life; and, probably like many of the others, he had been unable to refrain from extensive erotic fantasies. Yet the "dreams" provided an outlet quite regularly, until at 25 he was "turned down" by the girl with whom he was in love. At this, the nocturnal emissions stopped short for some six months; a period during which he worked "against the most grinding pressure" of extreme sex restlessness, with continual sex fantasies and seminal seepage. At the end of that period the nocturnal emissions started again, but with very incomplete relief. A year later, upon the recommendation of a medical student, he tried the masturbatory "way out." The relief was so marked that this adjustment was continued, with one period of abstinence for three months ("just to prove I could stop if I wanted to"), until he also married.

In at least two cases—said by some writers not to be unusual—the accumulation of seminal fluid, every week or so, was accompanied by testicular pain; and this in spite of an active life. The pain would persist until relieved, in one case by going to a prostitute, and in the other by a "dream" or a masturbation.

One wonders how much of this apparent need depends on early sexual arousal. As is well known, boys are very subject to early arousal through various environmental conditions; and there is no reason to think the men cited here were more innocent, even though more principled, than the average. The second case just cited, the man whose "dreams" stopped when his love affair did, and who resorted to masturbation thereafter, suggests especially some efficacy for the factor of arousal; as does also the first case cited under 11 above (Case 13, who practiced masturbation only after marriage during periods of absence from his wife). Indeed, it is commonly observed that the period after a serious erotic thwarting is often one of extreme sex pressure, in men at least. At such times, if a marriage "on the rebound" does not occur, a man is very liable to "cut loose."

In support of this observation, the writer will cite three individuals not otherwise included in the study. One, after his engagement was broken, was advised by his physician to "go to a woman and have it out," which he did. Another had had intercourse with numerous girls until he became enamored of one of his own social class, whereupon he became celibate and remained so for several months. Then this girl wrote him, with kind regret, that she knew that his intellectual and aesthetic tastes were so different from hers that he should not think about her any more. When he learned that she meant what she said, he presented an extreme picture of restrained restlessness. He brooded for some days, sought advice from the present writer, and got the usual platitudes, which did not seem to satisfy him. Finally, after another day or two, he disappeared one afternoon and came back the next morning somewhat listless but markedly "smoothed out." Upon inquiry, he confessed with a smile that he had spent the night with two girls, during which time he completed intercourse eight times. He seemed as much surprised at himself over this phenomenon as was a third man, one of very average physique, who was astonished to note that, when he finally married the girl he was in love with, he had complete intercourse with her on an average of three times a day for the first six months.

During the period of falling in love there appears to be accumulation of sex tension; a point which seems significant for the psychology of motivation, as well as for the theory of sublimation.

It is interesting to note that none of the men reporting masturbation manifested any tendency to excessive indulgence. True, in only a few instances were the frequencies alluded to; the point was not thought important, as individual differences were assumed, and good health was evident in all (with the one exception cited previously). A few subjects, however, mentioned their rhythms, and the writer has no reason to think them atypical. One subject masturbated once or twice every three or four days; another, two or three times together at intervals of some fourteen days; a

fourth subject "got restless" about once a month, when he would have "a little cluster of masturbations over several days," after which he would "never think about sex" until the next period came around. A fifth subject reported that he could get along equally well by masturbating one time every three or four days, two times once a week, or several times once a month; illustrating once more the accumulation-of-tension idea of the preceding paragraph.

This last subject, the one who commenced masturbation when his "dreams" were inadequate after a love affair, mentioned a "sort of diary," which he placed at the disposal of the investigator. Of course, a diary of this sort may be cause for suspicion of morbidity; however, the man did not seem morbid, but only objective and interested in social problems.

The first part of the diary record consists of counter suggestions and arguments against the erotic suggestions in Freudian literature. For example: "Imagine the suggestive effect upon the *digestive* apparatus if a lot of physicians were to decide that six meals a day would be best for everybody!" Another suggestive argument likened the body to a confederation of states, between which customs and immigration lines interfere with natural development; so that a common interest, "a live national issue," should make for free diversion of forces from one province to another as in war time (sublimation, precisely), to the end of the best life of each through the success of the whole. After further reflection, however, this entry appears: "It may be true that different people have different sorts of customs lines. I am sure, though, that the 'national' kind of person is the kind that can live best. *I will be that sort!*"

In the entry dated a month later there is a suggestion of hospitality toward some new outlet; very much like the increasing tolerance for cigaret smoking by girls in the advertisements of 1928-1930. "For the good of the whole," our subject writes of his platonic republic, "it may be necessary to keep the population down in any province. Perhaps even the nation would be helped by getting rid of that extra population in short ways. But this would not prevent more population. All waste is uneconomic. Better starve that pro-

vince so the population cannot increase so fast, and keep the national lid on, until the pressure falls back to normal. If this takes force from other provinces, the happiness of the nation will be worth it. Besides, repression might cost no more than expression would! Also, perhaps conflict creates progress, as some sociologists claim!"

After a few more weeks, however, there is a definite change in tone. Evidently reflecting on the work of the endocrinologists, the subject writes: "Balked sex: danger:—no alimentation:—exhaustion. . . . Why not follow Mill's advice to the state—restrain individual parts only when they interfere with other parts?" Accordingly, five months after the beginning of the record, he makes this entry: "After several days' pressure [of sex], I got talking with Z [the medical student] about sex and work. He said he couldn't see why full glands should help one's work. This was just what I had been thinking. After thinking some more, I decided to try masturbation. I tried it in the evening, and slept well. The next day was uncomfortable, but after that I had the best week's work for months."

From this point on the record is mostly of masturbations, with occasional comments. At first, a few of these comments reflect the strangeness of the adjustment, and some residual uncertainty about it. Then there is a period of seeming equilibrium on the new adjustment. Next comes notes on a deliberate return to the D basis for a dozen weeks. (As it happens, the subject "did not find it particularly difficult to stop [masturbation]; it was only inefficient, because my thoughts turned more from work to sex, like a hungry man's thoughts about food." This one report thus fails to confirm a statement by Elliott and Bone [23, p. 79] that the experience of masturbation makes it much harder to break off again;¹⁴ although the present case is quite likely a very different type from one for which that statement may hold good.) Finally, as the entries show, the subject decides to return to the masturbatory adjustment until he

¹⁴Another author states that "the habit [of masturbation] established becomes as hard to correct, if not more difficult to conquer, than the liquor or opium habit" (Stowell, 113, p. 127); a statement which to the present investigator seems probably true when the masturbation is used, like a drug, as escape.

Most writers on this topic enlarge upon "the possibility of over-indulging and the habit of overindulging"; e.g., Wittels (131, p. 141 as quoted), Moll (78, p. 181).

can marry; and, after a few minor comments then as to "the reality of sex," the record stops.

Throughout the entire period of the record, the subject's regular intellectual effort, physical exercise, companionship with both sexes, and various forms of recreation, seem to have been well balanced.

This record is summarized on the chart on page 51, except that the record is incomplete for a considerable period between the return to D and the final return to M. The subject reports, however, that the actual completion of the D record (which begins on the fourth line of the chart) would not differ materially from what is there now; and that the last two lines, after the break, seem typical of the adjustment that continued for several years, up to the time of his marriage.

The height of the little dashes on the chart indicates amount of "sex tension and nervousness," i.e., physical restlessness, insistent erotic fantasies, and general inability to concentrate effectively.

[Perhaps this restlessness, which, according to the report, often approached the feverish, was a basis for the medieval notion that "such accumulation of human semen must be dispersed if a poisoning of the blood was to be averted, and on the strength of this belief even boys of twelve were sent to the brothels" (Michels, 77, p. 29).]

This case shows periodicity of sex restlessness; liability of that restlessness to persist somewhat after only one masturbation at the intervals shown; apparent interchangeability of masturbation and nocturnal emission, as sex relief; and uniform efficiency after a sufficient relief.

Not shown on the chart is the surprising fact that upon two occasions this man made a local amateur athletic record, in a line requiring strength and endurance, on the day after he had secured relief through masturbation. In this connection the writer is reminded of a distance runner who made a new world's record one afternoon only a few hours after having sexual intercourse with his wife. (He spoke of it privately, of course.) Judging by a number of other comments in the case history just cited, such instances must not be


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"Great tension":  -- -- *
"Secc tension":   --
"Smooth-running": -- -- -- -- --

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FD FD (page missing)

(Here a break of six months)

r D

{See text for explanation)

- D—a dream with emission
 P—fantasying sexually when wakeful
 L—late to bed that night
 r—a rest (lying down)
 *—a masturbation
 -- —one day (24 hours)
 Each long line except the first and fourth stands for 21 days.

unusual. "Enjoyed a great game of [an athletic sport] this afternoon--guess it was because I played so well"; "Hated to quit. . . [an athletic sport] this afternoon--felt as though I could keep on for another hour"; or, "A great discussion of that . . . [technical] problem with . . . and . . . this evening"; "My paper for . . . went off very satisfactorily today"; comments like these, entered within a few hours, or a day, after a masturbatory outlet, time after time, call in serious question the view that a sex expression must weaken the male, not only immediately but for some time after.¹⁶ Briffault's (6a, Vol. 3, p. 355; 6b, p. 119)

¹⁶"The old phrase, *post coitum triste*, is illustrated in [sexual] excess of all forms, and especially in self-abuse," said Hall (37, Vol. 1, p. 442). "Masturbation . . . is incompatible with athleticism and all forms of keen, eager, mentality or even artistic power" (38, Vol. 1, pp. 463-646).

—The origin of the notion that any sex expression weakens the individual is to be found, apparently, in primitive thought. Woman being weak, by contagious magic she must weaken the man who touches her (Crawley, 13, p. 72). Also, various injuries to the male organs may have acquainted the savage with the relation between soundness of those organs and virility; and contagious magic, as well as numerous analogies, must have suggested that loss of semen means loss of strength. (Cf. Crawley, 13, p. 72.) There is the fact, too, that for a short time loss of semen does mean arrest of strength; a practical point which must have had much to do with the taboos against women's attendance on military expeditions. Further practical facts which came to be understood at various times were that sexual abstinence prevented the burdens of pregnancy and disease.

We must recognize the more general taboo idea, naturally reinforced by notions of weakness or worse from breaking the taboo. Sex expression was taboo at certain times to avoid the envy of the gods (Briffault, 6b, pp. 45 ff.); to store up energy in nature for the use of other living forms, or for the gods (May, 73a, pp. 10-11); when a dualistic ontology emerged, denial of the flesh was believed favorable to the life of the spirit and its true earthly institutions

at this point seem more accurate: "The dic-
ne animale post coitum triste,' is of very
 th; the normal condition of the healthy
 is respect is one of satisfaction, and has as
 to the state of depression as the repletion
 vs a meal." "Postcoital sadness is not a
 of natural history, but of Christian pa-

plain a part of the regular improvements
 noted by this subject in terms of the re-
 straction from within. A part, however,
 ve from the enhanced hedonic tone which
 time after the pleasure of relief (cf. Hall,
 pp. 455-456); which hedonic tone may
 rn, from enhanced metabolism or other
 ological conditions. At any rate, the bit
 presented here seems to go distinctly
 bliminal idea that economy here means
 energy there, and to point rather to the
 djustment here aids general adjustment,
 general, heightening of some powers means
 of all.

. 35 ff.; Briffault, 66, p. 60); and visions resulting
 asceticism were thought to have a divine import.

origins for the taboo for the strong may be found
 tendency for intercourse to refresh the man's love for
 by a kind of aura, for his children. This tendency
 against that *freedom from family attachments* urged
 Lord Kitchener. From the other side, as is known by
 rvers, unsatisfied sex hunger tends to make the male
 ent with his family ties, possessed of an animal rest-
 lition quite favorable to warlike undertakings, parti-
 as under primitive conditions, sex license was the
 l of victory.

Not inconsiderable is the evidence that enlivening the whole individual strengthens the individual's sex readiness. As that classic rascal, Ovid, observed, "While hearts are joyous, and not closed by sadness, then are they assailable; then with soothing arts does Venus steal on apace." Among primitive peoples the coincidence of sex activity with festal occasions is well known. Malinowski notes particularly the sexual stimulation that comes to the Trobrianders with their festival dances; and he describes the way these people choose aesthetic surroundings for their sex plays.¹⁰ In our own civilization the sex desire that follows upon great physical excitement, as in war and athletics, is not unknown; and from a number of clinical observations the writer would guess that times of general excitement, whether through the thrills of mountain

¹⁰Ovid (86, p. 393); cf. similarly the passage from Hume, page 70 of the present study, *infra*; Malinowski (71, pp. 210-236, 243-260, 276); likewise Seabrook (106, pp. 42, 219); various publications of Ralph Linton; and Crawley (13, pp. 107-112), who emphasizes however the periods of abstention as a basis for the periodic orgy. Cf. the discussion and cases above, pages 46-48.

One wonders whether the reported coincidence of the annual peak of sexual activity with the summer solstice (Hall, 37, Vol. 1, pp. 502, 454) suggests any relation between ultra-violet radiation and sex vigor!

Hall (37, Vol. 1, p. 454) did remark that "poor condition, overwork and undersleep tend to infrequency" of sex dreams. Cf. Lashley's (62, p. 197) report that severe undernutrition abolishes the sexual reactions, probably through "a general reduction of reflex excitability through disturbance of metabolism."

Mr. James E. Peabody communicates the following: "One of the greatest . . . quarterbacks . . . told me that after a football season, with its strenuous training, was over, he had such a superabundance of energy that he sometimes had as many as six emissions in one night, and that this never hurt him a bit." This observation, though interesting for the relation of sex to vigor, is of course unclear for the question of sublimation as such without a comparable report for a period of training.

climbing, or political upheaval, or artistic inspiration, so long as they do not produce actual fatigue, distinctly stimulate rather than reduce the sex relations between married people.

It must be remarked that the psychology involved here is complex. The whole psychology of "stale-ness" highly important but little understood—would seem implicated, as well as the psychology of escape. But whatever the ultimate interpretation of these phenomena of sex and general vigor, the theory of sublimation is not reinforced by them.

So much for the frequency, the danger of excess, and the relation to health, of masturbation in these subjects. There are other questions which have perhaps more psychological interest. How satisfactory did the subjects find this "adjustment?" Did they look forward to any change? What have they thought about it in retrospect? And, finally, how have these men "turned out" emotionally? On these important points, the investigator's data are unfortunately limited. He has, however, certain impressions and comments from apparently typical subjects.

At the time, no individual indicated that he regarded masturbation as anything but a makeshift. "It is better than nothing, once in a while," said one. Another, when asked, said that "of course there's nothing to it except as a means of relief." "It is pleasant while it lasts," observed a third, "and you feel better afterwards; but that's all that you can say."

A fourth subject whose adjustment was masturbation, a subject from a different professional interest group than the long case record cited, but likewise disappointed in a love affair some time before, broke out passionately in some letters:

"Taylor, these are my conclusions:

"1. The sublimation theory is bunk. We all get sex experience some way.

"2. Masturbation is better than fighting against nature, but,

"3. I believe that the normal sex act is best—especially as one gets older. No one has experienced more erotic pleasures than I have—they are better than an ascetic banishing of sex—but I believe they do us injury. For they are often mere mental excitement without a corresponding physical expression. We easily let them occupy too much of our time. Therefore, it seems to me that sex intercourse—and that is more than mere union—it is all the loving and caressing too—gives complete satisfaction; it more completely drains us of all our impulses and desires. We can then more completely forget our sex nature for a time, and when the time comes for another meeting it has a fresher, keener delight. . . .

"There is a man working here who is about 45. He has two children who have both been to college. He has a \$10,000 job. We have talked about these things very frankly. He had a mistress for two years before he got married some 24 years ago. I told him what I had been through and without mentioning any names or giving any clues, I told him about your list. Do you know what his remark was? 'All of the men on that list ought to be whaled in the head with a club and then each taken out to a woman. They are fighting against the strongest urge in nature.' That from an able man, middle-aged, father of two children in their early twenties—and one of them a girl.

"The moral question does bother me yet. But no moral standard—and particularly one in which I do not have *complete* confidence—is going to make me continue to experience such mental unhappiness as I have known the past four years. In fact, the one thing that has undermined my implicit confidence in the morality of chastity is the fact that I have seen it exact such cruel tribute from those who have been faithful to it.

"But God! What a struggle! Just now I know a girl who would willingly give me her body—a clean, *intelligent* girl; but can I bring myself to it? It is almost four years since I have known a lover's caress. Sometimes it is almost maddening to be without such caresses. At times I resolve to seek out the girl above and satisfy what is almost a supreme want. But there arises my ideal of what sex should and can be and then I ask myself, How can I?

"The situation is complicated by . . . [economic facts], so marriage is far distant—even an engagement which would bring with it many of the charms and caresses I wish.

"Meantime I am forced to continue the struggle. So far as the girl I have mentioned is concerned, the decision will be made soon. If I do not go to her, there will be a temporary lull—but before long another crisis will arise.

"Where I worked last summer a certain young libertine began to get intimate with a girl I liked. The result was that I told her what sort he was, and hurt her feelings terribly; but after strenuous effort on my part and after some indiscretions on his part, I succeeded in restoring her confidence in me as a gentleman.

"Having placed myself in that position it didn't seem to me that I could 'step out,' even with a prostitute! How could I warn her, and then go out on a party myself? My ideal of love is such anyway that I hate the thought of getting a girl pure in soul and body—one who may believe me to be similar—and to know in my heart that I am not. . . It seems to me sometimes that if I could be given five years of loving companionship with a pure, beautiful girl, I'd willingly give up the rest of my life.

"But after all, things could be much worse."

Later: "I believe that we should actually use sex as a means of becoming efficient instead of something to which tribute should be paid. That being the case, your problem becomes even more important and the nature of every individual's *modus operandi* vastly changed."

Nevertheless, he continued to restrict himself to masturbation; and when he became engaged to be married, he wrote as follows: "I am gradually realizing that there is something more than health and efficiency—it is hard to define it in a single term, but I like to call it *honor*. And increasingly I believe that honor, tenaciously maintained, will create both health and efficiency. . . Increasingly, too, I lean towards an idealistic philosophy."

Though this citation is perhaps extreme, no one of the cases manifested any desire to remain on the masturbatory adjustment longer than necessary. Several of the men were engaged to be married, and the writer's guess is that all hoped to be married as soon as

reasonably possible. In fact, more than 72% of those whose adjustment was limited to M are known to have married now, and several of the others expect to marry soon.

No systematic effort was made to collect retrospective judgments regarding masturbation. Even if a complete canvass were made, the value of such judgments would seem reduced by the evident difficulty happily married subjects have, despite their willingness to cooperate, in reconstructing an emotional poverty which is now overlaid with a normal emotional life. As Mayo (74, p. 421) says, "Love is in one respect like food: it matters most when one hasn't any"; or as Freud (33, p. 214) remarks, "It is easy to show that the value the mind sets on erotic needs instantly sinks as soon as satisfaction becomes readily obtainable. Some obstacle is needed to swell the tide of the libido to its height." Still, the writer has recorded a few comments.

One subject wishes he had begun to masturbate several years earlier than his twenty-fifth year, so that his mind could have been more free from sex matters between times. Several subjects feel that no real harm resulted from their masturbation, yet that a mistress would have been better. One writes: "I wish it were possible to keep the sex instinct in control until a boy is about 21 or 25; and then grant him the privilege of intercourse in marriage or outside. I think it is inhuman and damaging to the average man to keep him away from a woman until he is 30.

"Of course, my case may be peculiar. . . But, from my viewpoint, a man is better physically, mentally, *and spiritually*, if permitted a reasonable sex program with woman. I know the arguments to the contrary—disease, debauching of women, illegitimacy, and so on.—In view of everything, I don't know what to recommend. . .

"I am happy and efficient, and work best, only when enjoying a regular sex program."

Another man, a few years after his interview, wrote: "I have cut the Gordian knot. I have a mistress." To him this query was sent: "Is masturbation anything like the relief to free a man for working that intercourse is?" He replied: "Emphatically, no. The former may remove an obvious irritation but it does not necessarily clear the mind as much."

Still other subjects feel that, to avoid unfairness to girls in general and to mistresses in particular, the masturbatory adjustment, though a very poor one, was the best under the circumstances.¹⁷ Several advocates of "the single standard" are emphatic, however, that the ideal adjustment would have been early marriage; an adjustment not effected in their cases, in a few instances no doubt because of feelings of personal inadequacy, but in most cases because of (1) limited means, (2) unwillingness to ask a girl to live "on her own" in view of social expectations, (3) not knowing the right girl, and (4) not knowing how to know the right girl.¹⁸

At present writing, as remarked, more than 72% of those whose only adjustment (aside from occasional "dreams" perhaps) was masturbation are known to have married, and, we may add, with every evidence of normal happiness. Compared with the group of all who had other adjustments, this is a normal showing; since only 72¾% of the subjects with other adjustments are known to have married—a difference of less than 1%, insignificant with so few cases.

¹⁷Cf. A. Forel's conception of sex desire as something to do no hurt to another with (cited by Menzies 76, p. 88).

¹⁸Evidently Jung (57, pp. 213-216) would approve this youthful cautiousness. "A woman of twenty is as a rule older than a man of twenty-five," he says, "in so far as psychological judgment is concerned"; though "very many women have no understanding at all of masculine sexuality." "With many men of twenty-five psychological puberty is not yet completed"; hence "the weakness of a man's judgment at the time of psychological puberty should prompt him to reflect very deeply before risking a premature choice of a wife."

No effort was made to check with these subjects the current psychoanalytic generalization that masturbation when practiced over a long period makes a normal married life unlikely if not impossible. Two important cases run distinctly contrary to that generalization, however.

The first was one of several subjects who began masturbation before they were 10 years old and continued it for 20 to 30 years, yet with no visible effects either upon them, upon their married life, or upon their children, so far as known. To an inquiry as to whether this subject could detect any unfortunate result in his marital sex life, he replies:

"As it seems to me, my sex life has been essentially normal, both before and after marriage. Since the age of eight until my marriage I had masturbated on an average of once or twice a week. I never went more than a month or two without masturbation, and this only on a few occasions and by great effort. Since my marriage I have had no desire to masturbate. I have had intercourse with about the frequency that is normal for me, judging by my pre-marital orgasmic record, namely, once or twice a week—oftener when not working hard, and less often when working very hard." (The other subject reports the reverse ratio: more frequent intercourse, more work.) "The first month after marriage," the present subject continues, "I had intercourse more than thirty times. This, however, would not have been possible, or desired, if I had not been free from my work for that period.

"Within the first month of married life I learned to delay the orgasm as much as half or three quarters of an hour. My guess is that the psychoanalytic judgments you inquire about are based on nervous cases only."

The second subject was one who took up masturbation deliberately, as a result of his own thinking about nature, when in college, and continued it for nearly 10 years. He is also the one, cited on page 48, whose masturbations were clustered, several within a few days, at intervals of about a month. After a half-dozen years of married life he writes: "Incidentally, all my past vagaries have had no apparent influence upon my married life. I am quite content."¹⁰

¹⁰It is interesting to note that all of Peck and Wells' (88, p. 714)

Finally, with regard to these men reporting masturbation, the investigator is unable to note any inferiority in their later professional activities, as compared with the men of other adjustment groups.²⁰

most actively heterosexual individuals report masturbation, though "in quite varying degrees."

The following observation, reported by another subject, is apropos: "The boy who taught me to masturbate (he was 15 then) continued to masturbate until his marriage at about 28. For years he was a plumber, and now he is a farmer. He has always been well."

Cf. similarly Robinson (101, pp. 391-394).

[It should be remarked that not all these subjects were taught to masturbate. Some were. No effort was made to find how the men began. The investigator's guess is that the figures for the beginnings of masturbation in these subjects would not be very different from the figures for other groups (Hamilton, 43; Exner, 28a, pp. 16-28).]

For the psychoanalytic views see the next Note.

²⁰The incidental observations just given, incomplete and impressionistic though they are, are interesting in relation to the current statements about "the type of personality given to masturbation"—statements too often based upon data no more complete or considered than the above.

We have to begin with the psychoanalytical generalization that geniuses (meaning individuals who achieve preeminence) are narcissistic (Martin, 73, p. 66); that because "the masturbator . . . loves himself . . . remains wrapped up in his own interest in himself, quite unable to give adequately in the social scheme of his relationships . . . he remains seriously crippled in all creative directions," (White, 127, pp. 29-30). [Pfister's (90, p. 438) statement is similar, as is Brill's (8, p. 155).] According to some authors, masturbation not only expresses egocentricity, but produces it (Pfister, just cited).

Masturbation is thought further to immerse the individual in a world of fantasy with intolerance of reality (Wickes 129, pp. 290-291; Hirschmann, 47, pp. 18, 22; etc). It thus favors "an infantile condition" which predisposes to psychoneurosis (47, pp. 22-23).

Masturbation is said to lead to *ejaculatio praecox* (Hirschmann, 47, p. 18). According to Robinson (102, p. 52) it is usual to find that masturbators are unable to be normal in marriage. Robinson admits, however, that, while cases in which evil effects are absent

The likelihood that masturbation might develop into an escape mechanism, like alcohol or drugs, seems slight for adults as significantly engaged with real problems and tests as were these subjects.

are "decidedly in the minority," there are "many cases of masturbation, and even excessive masturbation, which are not followed by sexual impotence" (102, pp. 74, 435-436).

More subtly, masturbation occurs "at the expense of high moral tone" (Meagher, cited by Eddy, 22, p. 43). It is "injurious to self-respect" (Collins, 11, p. 19).

Specifically, "its protracted indulgence, and continuation of the practice after maturity comes, often testify a mind prone to lose its balance" (Collins, 11, p. 19); and it is accordingly "to the hypersensitive" that the practice "may do great harm" (11, p. 20). In the opinion of another writer, "Its effects depend entirely on individual constitution," owing especially to the "mental processes that commonly go with it" (F. L. Wells, 122, pp. 93-94).

Cf., on several of these points, the references given in Note 2, *supra*.

On the other hand, a number of writers agree that "when masturbation is only practised at rare intervals, and *faute de mieux*, in order to obtain relief from physical oppression and mental obsession, it may be regarded as the natural result of unnatural circumstances" (Ellis, 24, p. 191). Under these conditions it is probably harmless (Moll, 78, p. 181; Menzies, 76, pp. 49-53, 94n¹; Jung, 57, p. 220). As stated by Stekel (112, p. 71), "Warum wollen die Ärzte nicht sehen, dass es auch einen Nutzen der Onanie gibt, dass der Autoerotismus zahllosen Witwen, alten Jungfern, Hagestolzen die einzig mögliche, sozial mögliche Form der Sexualbetätigung darstellt?" (Cf. 112, p. 138, similarly.)

Some writers even approve masturbation for normal adults whom circumstances keep from the more adequate erotic outlet. "A constant severe struggle against masturbation," says one, "may not only result in impotence, but also in very severe neurasthenia; and this is even more frequent than impotence" (Robinson, 102, p. 433. Cf. also pp. 354-355; 103, p. 255; Popenoe, 91, p. 133; the authors cited in Eddy, 22, pp. 41-43; and notably Robie, 98, and Long, 67). Another writer remarks that "personally I am unable to see the ethical beauty of keeping a lad so exhausted physically by overwork [to combat masturbation] that he is sexually impotent" (S., 104, p. 46). From this point of view, "Extreme and uncontrollable masturbation is a symptom of neurosis rather than the cause of it" (Dennett, 19, p. 105).

On the other hand, we must acknowledge that the Freudian view that "erotic fixation upon the individual's own genitals" represents an undeveloped stage, and that fixation subsequently upon similar genitals (homosexuality) is the logical next step in development (Brill, 7, pp. 171-172), does indicate *tendencies*, even in well-adjusted men. Moll (78, p. 184) remarks that "for such a development [into homosexuality] to be possible, it is necessary that very special influences should be in operation, more particularly a congenital predisposition, or the cultivation of the perversion by perverse imaginative processes---this latter, indeed, occurring very readily in masturbators." We can readily see how simple conditioning of the orgasm with the individual himself, with his male genitals, instead of with an attractive female, would seem to require strong impressions of the opposite sex to prevent other males from becoming prepotent stimuli for his own sexuality. And obviously the individual while masturbating is gaining no experience of how to win and keep the regard of a mate. (Cf. Stekel, 112.)

Again, the puritanically minded youth, with his moral notions of the goodness of good women and the badness of bad, and of the baseness of sex in general, may well fantasy not of the finer type of girl; with the result that he develops that all-too-common split in his emotional life, in which he is unable to marry happily because the superior woman does not draw out his sensuous nature and the inferior woman cannot satisfy his other desires in marriage (Flügel, 31, pp. 111-112).

Another possibility for abnormality, though in a more subtle sense, may be a tendency for years of masturbation, in very rational persons, to stifle the "tender emotion" component of the love life. This tendency may result from simple lack of practice of affection, also from periodic preoccupation with the sex need in abstraction from its normal emotional concomitants, and from that severity of mental attitude which comes from the constant realization of want. This combination of factors seems conducive to the complaint of many young wives to their husbands: "Either you want me all, or you don't want me to bother you"; "You can't seem to pet without going all the way"; "Sometimes a woman just wants to be loved." No doubt, this disparity between many men and women results partly from the differences in their bringing up; partly from the sheer economic stress to which young men are naturally subjected regardless of their sex adjustments; and partly from the continualness of sex hunger before marriage which in many men seems to make the sex factor paramount in marriage. There may be innate differences, too. But the question remains as to whether limitation to masturbation over a long period does not tend to increase the "fight and sex" mentality of the male to the detriment of his affectionate side.

Some subjects were rather clearly aware of such questionable elements in their situation. Although spontaneous heterosexual fantasies during masturbation were no doubt the rule throughout the group, one man went so far as to voluntarily direct his fantasies at the girl with whom he wanted to fall in love, with

the idea that this overt association of erotic emotion to her would help —which it apparently did. With most of the subjects, however, associations, and especially social relations with the opposite sex, were cultivated spontaneously.

In light of the ethical objections to promiscuity or temporary sex relations, there is perhaps no better statement of the situation for the masturbator than appears in the admirable brochure by Dennett (18, p. 14): "*Do not yield to the impulse to handle the sex organs in order to relieve the pressure which may occasionally feel overwhelming, unless you find that nature does not bring relief during sleep.*" Yet we must remember that various conditions, including sound sex education, sufficient association with the opposite sex, and normal waking relaxation,²¹ may insure that ideal "relief during sleep."

P and W (relations with prostitutes, and with other women, respectively), as sex adjustments, will not seem out of place in this study of supposedly ethical men, if we remember that women were resorted to by these few subjects ostensibly as the least bad of all the alternatives; the alternatives comprising, for them, mainly nervousness, masturbation, and women. The women chosen were those only who "would not be harmed" by the relationship; that is, women who had engaged in similar relationships before and were ready to engage in them again. Yet even with respect to these women, conscientious scruples asserted themselves.

²¹Cf. pages 38-39, *supra*.

One who had had several mistresses was shocked, in his interview, to learn of the "abnormal" state of so many subjects, those who masturbated. He presented his own adjustment in contrast. The year before as he was walking by a window a handkerchief fell at his feet. He picked it up, and handed it to a very attractive girl at the window. She acknowledged his gallantry with a smile which he remembered. On another day he met her walking; and it was not long before their flirtatious acquaintance became intimate. Although a steady realism was evident in their prompt discussion of their previous affairs, in their agreement that this one should be temporary only, and in their care in contraception, the romantic naturalness with which the relationship began continued throughout. He kept her photograph on his bureau; they wrote notes and sent little presents when too busy to meet; and at their meetings, they enjoyed going to concerts and dances.

It may be therefore that the regret expressed by this subject afterwards was because he had become more fond of the girl than he would admit. Still, his professed attitude seemed quite typical of his group, when he called on the writer a year later to express himself as follows:

"Taylor, you remember when I told you about my little mistress, I said that I thought that was how all the men on your list ought to be. When you asked me if she might not fall in love with me, I said 'No,' because I had told her at the beginning I was going to leave this part of the country after two years and get married. Well, she has fallen in love with me. And here I have taken two years of her time, when she should have been free to find a husband. She is the kind that ought to get married. She is uncommonly nice looking, and she is fond of children. She has a fine character, too. She would make some man a wonderful wife. She is still very young; so I hope she will find someone. But I wish it had been different."

VII

INADEQUACY OF THE CONCEPT OF SUBLIMATION

The foregoing observations, taken as a whole, go distinctly contrary to the reasoning that, since in human beings the exercise of sex "for the propagation of life is needed at only a few intervals," it therefore "is aroused in children and stimulated in adults not so much by its own spontaneous urge as by erroneous teachings and suggestive scenes and customs—in other words by perverse intellectual methods."²² Rather, with respect to men at any rate, we are impressed by the truth of Michels' (77, p. 26) statement that "the sexual need takes the form of an urgent impulsion . . . compared with the sense of hunger." Indeed, the evidence confirms Hall's conclusion "that normal, virtuous, unmarried young men have sexual periodicity."²³

²²Eshleman (26, pp. 330-331). Similarly, Marston fails to find any "cyclic love stimulus" in "the normal male, after maturity, at least" (72, pp. 320, 321).

²³Hall (38, p. 466; and similarly 37, Vol. 1, pp. 453, 501-502). Ellis' conclusion is the same (cited by Menzies, 76, p. 45). The point is taken as a matter of course, as far as periodic expulsion of contents of the seminal vesicles is concerned, by Geddes and Thomson (36, p. 241) and by many other writers.

Robie (100, p. 247) says: "My long experience among actual people of the better classes leads me to deny that the entire sex force can be absorbed in such a way [as through activities] without the greatest detriment to the individual unless the individual be sexually abnormal at the outset . . . Some actual erotic expression, or tendency to expression, must at times occur in every normal individual." Cf. similarly Dück (21, pp. 197-205); Shufeldt (110, pp. 245-251); and Nyström (84, pp. 361-370).

This means that there is in young men an irreducible minimum of sexuality, in the sense of cumulative secretion, stimulation from within, and erotic sensitization: a complex physiological process, glandular, circulatory, nervous, muscular. This nuclear eroticism is never transmuted or sublimated away. On the contrary, it requires and finds some direct outlet in every case. The precise form which this outlet takes will depend naturally upon various external and internal circumstances, as Allport has remarked.²⁴ In fine, to quote Malinowski (71, p. 371): "The sexual impulse is never entirely free, neither can it ever be completely enslaved by social imperatives."

It follows that the conception of sublimation, though undoubtedly pointing toward some real physiological and psychological processes, fails of scientific usefulness. Like all analogies when pressed beyond a certain point, it proves inadequate and misleading. At the outset, the conception of sublimation fails to take account of the irreducible minimum of sexuality in the young male. Then the conception overlooks the important point that that minimum can be varied only in the form of associated activity, and not significantly in intrinsic content. (Simple re-conditioning of lust to art objects, for example, would be fetichism, not sublimation.) Also, the theory overlooks the possible relation between sexual vigor and general vigor, remarked above, and developed further in the section which follows.²⁵ On the other hand, the conception of

²⁴Allport (3, pp. 69-76); likewise Dashiell (15, pp. 236-238, 250).

²⁵Pages 50-54, *supra*, and 78, 81-83 *infra*.

sublimation makes too much of the facts that, within certain limits, attention *can* be diverted, activity changed, and development modified.

The whole conception is bound up with a misleading metaphysical-psychological theory. In general, this theory assumes a common psychophysical energy which can be diverted into different channels much like the water in a system of pipes. This assumption, however, despite the significant developments of Gestalt psychology and Lashleyan neurology, does not seem to hold to the extent that the notion of sublimation implies.²⁰ In particular, the metaphysical-psychological theory in question seems inseparable from the theory that human pleasures, loves, and appreciations of things beautiful, good, and true, are essentially forms of sexuality.

Hence, before we can attempt to analyze the conception of sublimation more constructively, we must look to the theoretical foundations in the psychology of sex and love.

²⁰Köhler (60); Lashley (63); Lashley (62); Prince (94, pp. 207-208); Taylor (116, pp. 102-103); Bartlett (4, p. 98).

VIII

SUGGESTIONS FOR THE PSYCHOLOGY OF SEX AND LOVE

Our knowledge of the various urges and emotions is limited indeed; but such knowledge as we have suggests, after various writers, certain tentative formulations.

At the outset, rather than contemplate human sexuality as a metaphysical simple, we should acknowledge its complexity. From this point of view, Hume's type of analysis "of the amorous passion, or love betwixt the sexes," seems much nearer the truth than does the psychoanalytic conception. That there are practical values in the psychoanalytic idea of *libido* no one can deny: it lends some logic to erotic perversions, for instance, and to certain functional relations between components of the love life. But Hume's approach allows for these same phenomena, and makes some of them clearer.

Hume said that "the amorous passion," "in its most natural state, is derived from the conjunction of three different impressions or passions, *viz.* The pleasing sensation arising from beauty; the bodily appetite for generation; and a generous kindness or good-will." In more modern terms, we may call the first of these three elements the appreciation of beauty, or, simply, aesthetic response; without thereby assuming that this factor must be simple or that we understand it fully. The second element we shall refer to as lust; although

this again may be only a name for the conscious accompaniments of "a number of acts, each a definite response to a definite pattern of stimulation," as Lashley has described the objective sexual behavior of the white rat. Hume's third factor is less easy to label. As, however, he uses the terms benevolence and esteem in the same connection, we may assume that this third component includes what McDougall, Sharp, and others call tender emotion, admiration, and benevolence (in the etymological sense of the term).²⁷

Of these elements, McDougall would reduce admiration to wonder and subjection or negative self-feeling. The same author, further, speaks of elation as an element which, with wonder, subjection, lust, and tender emotion, is a factor in sex love. Elation, or positive self-feeling, according to this author is an important

²⁷Hume (52, Book II, Part II, Sections XI, IX); Lashley (62, p. 198); McDougall (68); Sharp (107).

—Lashley's statement of the *complexity* of what we have called here "the lust component" seems fully applicable to human subjects, judging at least by one detail reported by the subject whose M diary was given at length in the section on "The Several Adjustments." This subject noted that, at times of "great pressure," the restlessness was not always, so to say, erectile, even while it was penile; there would be periods when he craved simply penile stimulation without erection or lustful thought, and he would satisfy this craving by rapid sliding of opposed thumb and forefinger back and forth along his flaccid penis. This would give rise to "a pleasant glow from the tip of the penis back through the organ into the rectal regions." Yet this was not masturbation, in any usual sense at least, since the stimulus resulting from the pressure of the finger and thumb were "curiously limited—lustful but not sexual—without any erection at all," and without orgasm or even seepage; although erection could be brought on at will simply by "thinking sexual thoughts, whether or not the bit of rubbing was going on at the time." Cf. Note 33, *infra*.

Of historical interest in this context is Laing's study of Hume (61).

element in pride; and pride, as everyone knows, is commonly involved in sex love. (Malinowski observes the important rôle played both by pride in possession and by personal admiration in the love affairs of savages.) "Gregariousness," too, has been listed by some authors as a factor operative in "the amorous passion."²⁸

If we may list such items as these without any assumption of their completeness, ultimate simplicity, or absolute separateness, and without raising the question as to whether they are innate or not; if we may take such terms to mean, not faculties, but significant patterns of adult activity; and if we may assume that the arrangement of these patterns is different in different individuals—then we may attempt a list of this sort to take account of important psychological facts, and as a basis for some constructive criticism of the conception of sublimation.

For the purposes of this study, we shall employ the terms lust, tender emotion, aesthetic response or the appreciation of beauty, wonder, elation, subjection, companionship, and benevolence, as markers for functional components which may be interrelated in various ways, but which, in the adult, are not one. The fact that some of these components, notably companionship and benevolence, are developed through expe-

²⁸McDougall (8, pp. 132-135, 129, 59, 64, 68; 68a, pp. 393, 394); Malinowski (71, pp. 266, 271); Thomson (119, pp. 373-375). A most noteworthy analysis, of which Ribot says he "can find no other to equal it, nor any point which could be added or subtracted," is given by Herbert Spencer (95, pp. 253-254). In this analysis Spencer lists "love of approbation" and "an extended liberty of action"; which have not been mentioned specifically above.

rience, does not make them unimportant here. Indeed, for anything like a complete account of the significant factors, to companionship and benevolence and the others we shall have to add a variety of clearly habitual and purposive attitudes (purposive in the sense of conscious "set" or "temporary habit"); since now neurological evidence has been adduced for Woodworth's view that "a habit may become a drive."²⁰ Also, as basic processes, we must take account of stimulus and response, inhibition and facilitation (including what we shall describe later as "alternative response"), conflict, dissociation, learning, and integration. And, finally, we must recognize a certain general factor, which we may call simply metabolism, to account for that measure of increase or decrease of any component which is possible through organic strengthening and weakening.

This list of elements, once more, is not an attempt to revive a "faculty psychology." It aims rather to recognize differentiation of functioning. Neither does this analysis mean that the personality is merely a collection of parts. On the contrary, integration means organization; and it is quite possible that the various components may influence one another in subtle ways amounting to an emergent pattern in nature.

This general point of view derives support from a number of important facts, which it makes more intelligible in turn. First there is the possible separateness,

²⁰Lashley (62, pp. 192-202) refers to the neurological support for Woodworth's view. The view itself is presented in Woodworth (133, p. 104).

or near separateness, of the lust component. As Myerson has remarked, "Sexual union much more frequently than not lacks the sentiment of love. It is a hunger, and no more than the starved man forms any psychic attachment to the morsel of food that he devours, does the sexual passion necessarily attach any particular psychic value to the object of desire." Hence, in the words of Bernard Shaw, it is an "unworkable assumption . . . that the specific relation which marriage authorizes between the parties is the most intimate and personal of human relations, and embraces all the other high human relations. . . . This is violently untrue": the potential "impersonality of sex," to use Shaw's phrase, is too often overlooked. Among the Trobrianders, there is frank recognition of sex gratification as good in itself. In our civilization, this recognition has not been so customary, because of the traditional notion that sex is obscene—a notion which, according to Shaw, is "a blasphemy against life, and, to put it in Christian terms, an accusation of indecency against God." "So unwholesome an absurdity," he says, "could only have gained ground under two conditions: 1, a reaction against a society in which sensual luxury had been carried to revolting extremes, and, 2, a belief that the world was coming to an end, and that therefore sex was no longer necessary." Michels states that "no woman of a calm and elevated mind has ever felt any sense of injury or affronted honor in consequence of the sexual admiration of a man"; and that "the 'pure' woman is a fiction of the libertine. The libertine is one who suffers from a distressing cleavage

of the soul." Nevertheless, we have to acknowledge that this cleavage exists in many, owing to social traditions whose aim, pathetically enough, was virtue, instead of this sort of vice or pathology.⁵⁰

Another significant fact is the occurrence of tender emotion in apparent independence of lust. Even among the animals, evidence of parental fondness by both sexes, without sex activity (though not always), is well known. Hamilton notes particularly the isolation of this component in a pair of monkeys. "It was of interest," he says, "that although both the male and the female, after they had been caged together for some time, ceased to stimulate one another sexually as they were stimulated by new cage companions of the opposite sex, mates of a voluntarily established union who were thus separated would persistently call to one another and, if they were in adjoining cages, nestle against one another through the separating wire netting. When mates who had been separated for a few days were restored to one another they would rush into a face-to-face embrace (this is not the copulating position for monkeys) and utter sounds which are characteristically uttered by all monkeys when a disadvantage has been overcome or escaped." He concludes that these observations, together with various studies of the human species, "support the view that there is a mating tendency which can and often does function sep-

⁵⁰Myerson (83, p. 507); Shaw (109, pp. 160, 193); Malinowski, (71, p. 264); Michels (77, pp. 217-214).

On cleavage, cf. Scott (105, p. 213); also Flügel (31, pp. 111-112).

arately from the tendency that leads directly to copulation."⁸¹

The same point is evidenced by the way the Tanala and Betsileo tribes of Madagascar differentiate between affection between persons of the opposite sex and sexual attraction. A man and woman who love each other, but who are unable to marry because of relationship or have found each other physically unsatisfactory during premarital relations, will go through the ceremony of *fatidra* or blood brotherhood. This ceremony, says Linton, "establishes a relationship between them closer than that of brother and sister by the same mother, and sexual relations are thenceforth unthinkable. They would be punished by prompt death at the hands of the ancestral spirits. After making such a bond the couple can be together as much as they wish without chaperonage and a man may even come and live in the house of a married *fatidra* sister in the absence of her husband without exciting gossip.

"Married people who think it advisable to separate, but who feel a deep affection for each other may also perform this ceremony. Such separations are usually due to the fact that the union has proved sterile and both believe they may have children by other partners,

⁸¹Hamilton (42, pp. 322-323).

Marston comes to the same conclusion (72, p. 287).

For instances of failure of this isolation of the affectionate response from the erotic, cf. Hamilton (42, pp. 311-312; 41, p. 307).

Interesting but not essential for our study is McDougall's (69, p. 561) opinion that, "while the excitement of the sex-instinct tends naturally to lead on to the excitement of the protective [or parental instinct, which in McDougall's scheme is the basis of tender emotion], that of the protective has no such natural tendency to awaken the sex-impulse."

or to the discovery that they are within one of the prohibited degrees of relationship, some of which are very remote. A married couple may also make *fatidra* without separation as a sign of their deep affection, but in this case the right to sexual intercourse is reserved by the parties when making the bond."

'This custom is particularly significant in that among these people divorce is easy, and "both tribes are polygynous and are tolerant to sexual relations outside marriage as long as the incest regulations are not infringed." In other words, there is nothing compulsory about *fatidra*, yet individuals often choose to enter this state.⁸²

'The third component on our list, namely, aesthetic response, likewise often functions independently. Even among the wanton Trobrianders, where, as elsewhere, sex activities are commonly surrounded with many forms of beauty, the aesthetic life flourishes also on its own account. (Malinowski, 71, pp. 243-260, 276, 291.)

It would be superfluous to multiply examples of this sort of separateness. The point is that under various conditions, lust, tender emotion, and aesthetic response, respectively, can appear in marked isolation, and without evidence of essential support from one another. We may go further, and observe that the other components of the love life seem to be in the same case: wonder, elation, subjection, companionship, benevolence, and the habitual and purposive attitudes which

⁸²Communicated by Professor Ralph Linton of the University of Wisconsin.

often enter into erotic situations, may all occur quite apart from the sex function.³³

On the other hand, we must recognize a significant tendency for the several elements in sex love to go together. Whether the explanation be genetic community of the emotions, or associative relationship, it nevertheless seems certain that, as Hume said, "the appetite of generation, when confin'd to a certain degree, is evidently of the pleasant kind, and has a strong connexion with all the agreeable emotions. Joy, mirth, vanity, and kindness are all incentives to this desire; as well as music, dancing, wine, and good cheer. On the other hand, sorrow, melancholy, poverty, humility are destructive of it. From this quality, 'tis easily conceiv'd why it shou'd be connected with the sense of beauty.

"But there is another principle," he explains, "that contributes to the same effect. . . . 'The parallel direction of the desires is a real relation, and no less than a resemblance in their sensation, produces a connexion among them"; as when both beauty and hunger draw us toward food. "From these two relations, *viz.*, resemblance and a parallel desire, there arises such a connexion betwixt the sense of beauty, the bodily appetite, and benevolence, that they become in a manner inseparable; And we find from experience, that 'tis indiff-

³³Cf. Woodworth (133, pp. 170-176).

For examples from anthropology see Crawley (13, pp. 79ff.); Briffault (6*a*, Vol. 1, p. 142; Vol. 2, pp. 151-152; 6*b*, p. 170).

On fractionability of complex "instinctive patterns" cf. Murphy and Murphy (81, p. 50).

Cf. also Note 27, *supra*.

erent which of them advances first; since any of them is almost sure to be attended with the related affections. One, who is inflam'd with lust, feels at least a momentary kindness towards the object of it, and at the same time fancies her more beautiful than ordinary; as there are many, who begin with kindness and esteem for the wit and merit of the person, and advance from that to the other passions. But the most common species of love is that which first arises from beauty, and afterwards diffuses itself into kindness and into the bodily appetite. Kindness or esteem, and the appetite to generation, are too remote to unite easily together. The one is, perhaps, the most refin'd passion of the soul; the other the most gross and vulgar. The love of beauty is plac'd in a just medium betwixt them, and partakes of both their natures: From whence it proceeds, that 'tis so singularly fitted to produce both.

"This account of love is not peculiar to my system, but is unavoidable on any hypothesis. The three affections, which compose this passion, are evidently distinct, and has each of them its distinct object. 'Tis certain, therefore, that 'tis only by their relation they produce each other. But the relation of passions is not alone sufficient. 'Tis likewise necessary, there shou'd be a relation of ideas."³⁴

³⁴Hume (52, Book II, Part II, Section XI).

To the writer, as before remarked, this distinction between components seems not incompatible with organization, totality, or uniqueness of personality as a whole. As Thomson (119, pp. 367, 375, 368) says: "We reiterate once more most emphatically that love is synthetic. . . . It is composed not only of elements but many complex compounds within compounds . . . (and) the motive force of love as such is in this synthesis and not in the elements as such."

If this tendency of the several components to run together suggests the libido theory more than it does the analytic view of sex love— if this tendency to fuse does not seem to require the analytic view as much as the facts of isolation of those components did— it is at least true that the tendency to fusion does not require the libido theory. *Associative tendency, congruence, or even community of origin of factors in sex love, is very different from saying that these factors are one.*

With these two general facts in mind, namely, the occasional isolation of components, and their tendency to combine into a complex love pattern, we can the better understand a third category, the sex perversions. The dissociation of lust from tender emotion, the abnormal inhibition of lust, its association with various aesthetic and sensitive reactions as in the fetichisms and zonal perversions, the limitation of lust to states of pain, degradation, or cruel domination, as in masochism and sadism—all these phenomena become understandable in terms of dissociation and association of components, much as suggested by McDougall (69a, pp. 321-332, 561); as the writer hopes to show further in some cases not yet published. More subtle than the classic types of perversion, and difficult to classify, are the heartlessness of the lustful Cellini, and the simple sex attitude of the intellectual Kant; cases in

In particular, "where the aesthetic quality is absent, the purely sex instinct is likely to dominate to such an extent that it cannot be called love in any true sense: it is lust . . . It is doubtful if love can exist without beauty or aesthetic appreciation of some sort."

Hocking (48, pp. 49-50) speaks of the tendency of instincts "to share in the tracts of physical expression," and objects to the notion of "clean-cut division" between the several instincts.

which the aesthetic and tender reactions, if present at all in the sex setting, seem to have been so intensely attached to art itself or to aesthetic theorizings as to leave none free for attachment to a person.⁸⁵

A fourth set of facts which our theory helps to explain is the apparent tendency for general vigor or excitement to favor the arousal of the sex impulse. (Anger and fear, as is well known, inhibit the sex impulse *at the time*; but it is a question whether they do not facilitate its appearance later. Another apparent exception may be found in neurasthenic sexual hyperesthesia. This hyperesthesia, however, does not disprove a tendency for sex vigor to follow upon general health or excitement.) Cases of the coincidence of sex expression with bodily and mental efficiency have been cited above.⁸⁶ The relation between festivities and sex expression in savages, and the apparently similar connection between times of excitement and sex stimulation in civilized men, have been noted also.⁸⁷ In litera-

⁸⁵The emotional reactions of Benvenuto Cellini are shown in his *Autobiography*. As remarked by Courbon (12, p. 80), "Il semble que l'instinct sexuel chez Cellini s'en soit toujours tenu à ce premier stade de son évolution ou pour nous servir du langage de Féré (L'Instinct sexuel, Paris, 1902), il n'a d'autre effet que l'acte de conjugaison, et qu'il n'atteignit pas de degré plus élevé où les instincts relatifs à l'union permanente et à la protection des jeunes viennent se joindre à l'impulsion génitale primitive pour constituer l'amour normal."

Kant, according to Höffding (49, Vol. 2, p. 93), "alludes to the sexual instinct as a strictly isolated need of human nature, regards it from the purely sensual side only, and has no sense at all of its fine gradations, and of its possible connection with some of the most ideal feelings."

⁸⁶Pages 50, 54 *supra*.

ture, Sappho (125, p. xx) presents this tendency in its extreme form. For her,

"All thoughts, all passions, all delights,
Whatever stirs this mortal frame,
All are but ministers of Love,
All feed his sacred flame."

As stated by Herbert, "Even physical exercise . . . if not pushed to excess . . . may . . . stimulate the sex centers, for these are, after all, not an isolated system of the body, but are influenced in consonance with the whole bodily tone."³⁷ From another angle, Scott (106, p. 224) made the point that art and sex are alike "essentially an overflow of health and strength, an outcome of the highest metabolism of the organism." Lecky (63a, Vol. 2, pp. 123-124) thought that "what may be called a strong animal nature—a nature, that is, in which the passions are in vigorous, and at the same time healthy action—is that in which we should most naturally expect to find several moral qualities. Good humor, frankness, generosity, active courage, sanguine energy, buoyancy of temper . . . are much more rarely found either in natures that are essentially feeble and effeminate, or in natures which have been artificially emasculated by penances, distorted from their original tendency, and habitually held under severe control."

(This is, as we shall see, no argument for license.)

The congruence of vigorous general arousal and sex activity may remind us of the libido theory rather than

³⁷Cited by Robie (100, p. 247). Cf. similarly (99, pp. 229).

of the analytic view presented here, inasmuch as such arousal suggests a fundamental libido. The psychology of that assumption, however, has been examined, in the preceding section; and the findings of the present study go contrary to the theory that activity in other lines can dispose of the specifically sexual energies. Nor does the fact that loving behavior and aesthetic and other creative activities may be motivated by sex desire prove that sex desire is assuaged by such activities. With health or great energization, all the main erotic components, lust, tender emotion, aesthetic response, tend to expression, as a result of a general metabolic, not interchangeably libidinous, condition.

The subject (a very superior one) who shifted from M to W some time after his interview⁸⁶ was asked when he reported this change: "How much of the same relief of tension that comes through sexual intercourse could be found through sleep, athletics, art, and gay sociability?" He replied: "If any of the activities you mention are used as a substitute for intercourse, I think it would be found (1) that much more time would be demanded, and (2) that one of the forms of activity will not be enough—they will all have to be used to some extent. My observation during this period [of having a mistress] has been that I could go for an unusual length of time without physical exercise, without dancing, etc.; something which I found to be quite impossible before. On the other hand, it must be remembered that these various activities cannot be eliminated altogether. I have found, for instance, that after long restraint from dancing I wanted to dance and I had the same (non-sexual) pleasure from that activity as I always have had. The same would be true for any of the other diversions."

⁸⁶Page 59, *supra*.

IX

THE PSYCHOLOGY OF SUBLIMATION

From the data and theoretical analyses now offered, what understanding can we gain of "sublimation," that process which many people claim to find relief in, and which many psychotherapists recommend to their patients? This is the focus of the present inquiry.

At the outset, we must recognize the shifts of activity, attention, and energization, which occur constantly in daily life. The sublimation theory has placed especial emphasis upon the fact that the sex function is like the lacrimal, to the extent that it can be aroused to extra activity by inordinate stimulation, without such activity being necessary to its health. But the same is true of most or all of the other functions of the body. Take "the salivary propensity," for example. Although no measurements have been made within the writer's knowledge, it seems likely that the constant chewing of gum, or tobacco, must increase the amount of saliva secreted within twenty-four hours. In the same way a person with nothing to do but to seek erotic stimulation (and such other refreshment of spirit as would protect *that* interest from waning) could increase his orgasmic output markedly, we have every reason to believe. Furthermore, either of these forms of increased production, the salivary or the sexual, if carried beyond a certain point, would be at the expense of other forms of "self-expression": other interests would suffer.

The questions at once arise, Must the explanation for such "diversion of energy" be sublimational, or may it

be metabolic and neural? And are there any important limits to the process?

In answer, a part of the explanation for the process seems to be that, with increased arousal of any function, there occurs an increased energization of that function through an enhancement of the local metabolism; along with changes in resistance of the reflex pathways involved (Lashley, 62, p. 196). In other words, there are possible shifts of metabolic activity, delicately poised circulatory and other physiological processes which can function now here and now there, to meet the emergencies and special calls for development of the different organs of the body, aiding the production of saliva, or of sex secretions, for example, as required. To this extent, as the writer has argued elsewhere (117—quoting largely) we can agree with the libido theory; but this is quite different from saying that such shift of development represents a transmutation of the activity peculiar to one function of the body into the output of some other function or functions. It is also very different from supposing that such basic diversion of metabolism can take place without limit, and always to the profit of the organism as a whole.

(The report of one or two subjects that a short nap would abolish sex restlessness suddenly sometimes may be explained partly through metabolic changes; though inhibitions from rested higher centers may be a more important explanation.)

Another factor to explain shift of activity we may call simply "alternative response." This factor the writer (117) developed as the process by which, given

any two patterns of response, one pattern gains the right of way, while the other is completely or almost completely inhibited.

In its simplest form, this process appears in "reciprocal innervation" (Sherrington), in which, for example, contraction of the flexor muscles in a limb is accompanied by relaxation of the extensor muscles in that limb. The forms of alternative response which most obviously relate to the present study seem to fall into five general categories, as follows: If any impulse or tendency is balked, there may ensue an alternative arousal of (1) various striped-muscle patterns; (2) the emergency emotions; (3) the mechanisms of laughter and crying; (4) appetitive functions; and (5) thought processes—with various gradations and complications of these.

The frequent complications between the several types of reaction need not detain us, other than to *acknowledge them*; since our main interest is in the degree to which any of the types of reaction can be substituted for other types. Fear and anger may occur along with crying, or at least in rapid alternation with crying; the crying may be accompanied by angry gestures; restless activity of the limbs may be associated with thinking. Yet a number of examples could be cited in which the substitution of one mode of response for another seems very complete, either natively or through learning (117).

Now an important result of such alternativeness of response appears in that the unused alternative patterns, because inhibited before their arousal, so to

speak, do *not* persist as "balked dispositions" which press for "sublimation." The question remains, then, How far can alternative response apply to relieve the tensions of the organism?

Unfortunately for the adjustments of some people at some times, there are limits to the process. Alternative response is most effective, probably, in those situations for which the motivation is either a general condition, such as adrenin in the blood, or an intention, such as to take exercise or to solve a problem, for which one of two or more response patterns may be adequate. Yet even here some limitations appear. We do not know, for example, that "laughing off" the adrenin in the blood (through the chemical changes that go with any exertion) is as *economical* as is "working off" with the long muscles. And as for intentions, we observe that whenever the intention to exercise gets set on a specific form of exercise, or the plan to solve the problem turns into a determination to solve it by a particular method, much alternative response becomes inapplicable. Thus, in many of us, disappointment at being prevented from picnicking on Pushaw is incompletely assuaged by picnicking on Chemo; if Chemo is out of the question, and we have to stay at home and pitch horse-shoes instead, the undercurrent of disappointment is stronger; and if recreation of any sort is prevented, the urge to break away from routine becomes acute and persistent. (Cf. Zeigarnik, 134.)

Furthermore, a great many of our urges are vitally dependent neither upon general physical conditions nor upon goal-ideas, but derive from specific intra-organic

stimulations which must stimulate until relieved by specific circumstances. In this group come all the basic life-maintaining urges of hunger, thirst, respiration, circulation, heat, cold, pain, fatigue, elimination, probably other organic conditions including "restlessness or the need for action," and certainly, in the male, a vital part of "sex." These urges are relieved only, so far as we know, by the specific provision of nourishment, liquid, air, blood supply, and normal temperature, and by the removal of the causes of the pain and of the internal conditions of fatigue and the other organic states, including the removal of the internal stimulation to sex activity.³⁰

The fact that the urge to sex activity can be removed or reduced by responses during sleep, erotic day-dreaming, "spooning," and the like, though significant for social practice, is no support for the theory of sublimation. On the contrary, the way these processes seem to relieve sex irritation in proportion as they release specifically sexual responses is strong evidence against the theory, and leads to the practical implication that for the conscientious individual to strive to

³⁰The list of urges is taken largely from Dashiell (15, pp. 234 ff.) and from Curti (14, pp. 292 ff.)

Pavlov's (87, pp. 302 *circa*) observation that he could condition a dog to respond to a noxious stimulus with benign salivation does not establish alternative response as cultivable without limit. He found that there is a limit to such contrary conditioning; and that when that limit is exceeded—when say the noxious stimulus to which the dog has been trained to respond benignly becomes too strong—the animal suffers a nervous breakdown.

Specific objection to the idea of general substitutability of urges, even within certain of the 'Thomas-Park-Burgess' "four wishes," is made by Folsom (32, p. 144).

"transmute" his organic nucleus of sexuality may mean *excessive nervous strain* as well as *self-deception*. The better course for him would be to acknowledge the urge quite biologically, and then, barring opportunity for normal outlet under approvable conditions, to make the best adjustment that he can, profiting perhaps some from the observations presented in earlier pages of this study. But enough of the practical for the present.

The processes of shift thus seem to inhere in *adjustive metabolism* with alternation of response; and these functions are limited.

But the term "sublimation," as used in the literature, points to other phenomena besides shift. These further phenomena may be brought out by an example. As the study has been limited to masculine sexuality, we must forego the classic instance of the woman who sublimates through convent life, and shall examine instead the reactions of a young man in a similar situation. Let us imagine him to be highly emotional, sentimental, recently disappointed in love, and now entering a Roman Catholic monastery.

Evidently this young man's total tension of balked dispositions will be eased considerably if in his new environment he can find releasing situations essentially similar to those of which he has been deprived—situations which can release those response patterns that he had ready. The monastic environment offers a number of opportunities for just such benign release. For his thwarted tender emotion, benevolent impulses, and desire for companionship, there are all the persons of worship, the heroes and heroines of the faith, the par-

ishioners who need care, and the brothers in the order. His aesthetic appreciation responds to the adornments, the ritual, and the aspirations of the church. His wonder, elation, and subjection find expression through many aspects of the religious doctrines. Even the lust component of his original attitude may obtain waking release if that component can be reintegrated without great conflict through, say, religious fantasy, after the fashion of certain women mystics.⁴⁰ Thus the several thwarted urges of our subject get such outlet as they can, through forms of response as different from the originally intended ones as may be necessary, but in essentially their original introspective qualities.

This same sort of release is available for other than emotional components of the love attitude. All the intentions, purposes, acquired volitional patterns, which were pressing for expression, may find in the new life significant outlets for their behavioral tendencies. True, the precise intention to possess a certain girl cannot be satisfied; but there are persons, and a cause, that invite devotion. The anticipation of tender ministrations cannot be fulfilled exactly as expected at the outset, either; but the particular care of various heavenly personalities is available. Similarly, our sub-

⁴⁰The conception of reintegration is Hollingworth's (50, p. 19): "that type of process in which a part of a complex stimulus provokes the complete reaction that was previously made to the complex stimulus as a whole."

The women mystics are described in James (54, p. 347, and *passim*); in Moses (80, Vol. 1, p. 16); and in Leuba (64, pp. 70, 75 ff., 138 ff.). Perhaps the most perfect example appears in the *Exeritia* of Saint Gertrude.

ject's intention to establish an abode is realized to some extent in the place he has in the life of the monastery.⁴¹

⁴¹The reality of these intentions or purposive attitudes as dynamic urges becomes apparent when we consider everyday examples. A three-year-old girl who has set herself to bring in the milk toward getting supper is trepiduously disappointed to find that somebody else has brought it in; and even setting it out for her to bring in anew may not appease that intention to bring it in the first time. Occasionally, a very young child who has been forbidden some toy or activity just before bedtime may be heard to talk about it repeatedly during the night's sleep. Again, as Aikins (2, p. 192) says, "When a person has an obvious weakness . . . he is likely to strive desperately to compensate for it by some kind of conspicuous achievement; he gets fixed purposes that he follows desperately, and he cannot adjust himself flexibly to changing conditions that upset his program of self-vindication."

Just-forgotten intentions, as when a man comes to his desk expecting to do a particular thing first, then forgets that intention, with the result that he "just sits" for a time wondering why he does not get to work, illustrate the effective operation of these intentional attitudes in another way. The example given is closely allied to one type of "Freudian wish," the variety and reality of whose activities provide familiar illustrations of the same general principle.

The urges of habit, also—the musician's impulse to touch the idle piano keys, the land-locked sailor's craving for the sea, the vacationing urbanite's desire to get back to the noise and bustle—these phenomena are too familiar to require emphasis. The apparent accumulation of these desires, however, within certain limits, as in the "musical spree" the musician goes on when he returns to his instrument after a considerable absence, is worthy of note.

The apparent inevitableness of alternation in certain cases of multiple personality seems distinctly related to the accumulated "musical hunger" just mentioned; though the alternations of personality are doubtless more complex, involving disparate urges and neurological conditions more basic than acquired patterns. The same may be true of periodic tantrums and possibly of some epileptic fits.

From the experimental side, Zeigarnik's (134) investigation of the ability to recall uncompleted as compared with completed tasks, and of related phenomena, is illuminating. Evidently, uncompleted tasks—in proportion as they enlist the subject's interest, it would seem—function as very persistently stimulating situations. (Cf. also Carr, 10, p. 73.)

Still other changes happen to this subject, however. His new habitation affords a retreat from the old stimulations of his malady- from the physical presence of the beloved, her environmental associations, and all the social reminders of that situation. Hence the old associations can lapse, as new ones take their places. Thus the reponses which at first were reintegrated only by part of the original stimulating situation, come to be aroused in new combinations by new associates of those parts, until finally there is little similarity between the original patterns and those developed. Throughout, however, the elemental qualities themselves remain intrinsically the same, so long as the original urges persist.⁴² In time, such original urges as were aroused by the love affair to an unusual pitch will recede through disuse, if the new environment fails to stimulate them. This will be true especially in so far as the monastery provides distractions which are interesting on their own account. Effective inhibitions, too, that get set up, will play an important part.

A further significant set of changes that occurs during this period of readjustment in the monastery is the increased integration that accrues to the individual from healthful regimen, dignifying responsibilities,

Our theoretical formulations may or may not be adequate to explain these phenomena. The writer would conceive them in broadly deterministic terms, after the manner of Perry (89), Curti (14, pp. 173, 299, 302 f.), and Hull (51, 51a). The phenomena, at any rate, are real.

⁴²Cf. the analysis of this process by Hunter (53, 250, 253-255); and the discussion by Woodworth (133, pp. 175-176). The introspective constancy of the emotional components has been urged especially by McDougall (68).

inspiration from fine things, improved hedonic tone. Also, suggestions from the religious teachings, and bits of philosophic insight, may help resolve a number of residual conflicts. The net result is an increased ability to inhibit the unruly elements of the personality, and to live at peace in the new order.

Nowhere in this general readjustment do we find any real transmutation of emotion or libido. Only the shift from one activity to another, and the utilization of a certain amount of metabolism for special functions, approximate the popular picture of sublimation; and neither shift nor metabolism seems sufficiently libidinous and alchemistic to justify the misleading connotations of the conception we have had before us.

In fine, sublimation seems to reduce a congeries of processes. These processes include: limited shift of activity; reintegration and reconditioning of emotional components; release of intentional or purposive attitudes through similar volitional situations; diversion of attention to avoid the habitual irritants of any undesired impulse; the establishment of inhibitions; enhancement of hedonic tone, and with it integration of the organism, as a result of aesthetic satisfaction, social stimulation, and personal success; and elimination of conflicts, so far as possible, through suggestions, habits, and insights that come from new activities and new interests.

X

CONCLUDING STATEMENT

The foregoing analysis does not pretend to finality. The effort has been to present the current psychoanalytic theory of sublimation, to test that theory by appropriately chosen cases, to learn from those cases what we can about male sexuality, and to reinterpret "sublimation" accordingly in psychological terms. The results of this effort have confirmed rather than revolutionized the more usual conceptions of psychology. At the same time, a number of important socio-ethical problems have been touched upon, toward the solution of which this study has contributed only certain data, not final conclusions.

The study has not contributed final conclusions for social practice, because the data, although significant (in the writer's judgment) for the theory of sublimation and for our understanding of male sexuality, have very limited application. The conditions of graduate life so lack the security and homely rewards which every worker desires, that before we could generalize as to the best practice we should have data on subjects as superior as these but under conditions less hard; for example, where the struggle for professional survival has taken place before entering the graduate schools, so that the selected few could take their work more easily, which condition we saw eased "the sex problem" for some at least. Or perhaps graduate students could be trained to take their work more easily under present conditions: perhaps, after the usual eli-

mination of these who lack effective technique in hygiene and in methods of work, and the care which the survivors give to their own efficiency, these men could learn to maintain, in Thoreau's words, "a true integrity day by day." That result, though apparently in no wise affecting sublimation as a theory, might well affect sexual adjustments in practice.

In particular, for present conditions, no perfect solution for the problem of sex in the young adult male has appeared. Pending the arrival of the perfect social order that never comes, it would seem that any form of adjustment must bring with it both advantages and disadvantages. "Dreams" appear to fail many mature men who have to work hard; "spooning" is a curious make-shift, probably not lacking in social and other disadvantages; "masturbation" fails to develop the normal emotional and social life, if it does not stunt that life; "women," and "prostitutes," as "adjustments," involve several kinds of deprivation and danger, particularly to the women themselves; and early marriage, which suggests itself as an alternative, runs all the risks of youth and inexperience.

Yet, under the conditions, early marriage may be the best way. The few instances that the writer has seen of married graduate students of the type studied were instances of contentment, good work, and good play. These few examples support the impression of a dean of women in a coeducational college, cited by Lindsey and Evans, "that the young couples in college who were married were under less strain than other students, and that they were far more successful and contented in

their work after marriage than before." There is apparently no danger whatsoever of sexual excess in such unions. The reports of married men, like the reports of those subjects whose adjustment was masturbation, are unanimous on this point. It is the lack, not the continued presence, of opportunity for sex expression that wastes time and energy. As for the economic factor, if it is not true that two can live as cheaply as one, it is nevertheless true that two can live as cheaply as two.

Allport's statement of the case is very convincing. "One of the most serious problems of our higher and professional education," he says, "is the restlessness and distracting influence produced by enforced celibacy long after the sexual maturity of the student. Much time and energy is diverted from study into seeking such sex excitements as chance and a conflict with the sense of propriety may allow. If this sexual effort could be allied with the goal of scholastic and professional attainment, as it might be in some cases by early marriages with child-bearing deferred, instead of being allowed to detract from serious study, the gain both in work and happiness would be enormous."⁴⁸

Two things seem essential, if such marriages are to fulfill their function. One is that society acknowledge them and all their conditions. This is necessary, both for the spiritual integrity of the young people them-

⁴⁸The citations are from Lindsey and Evans (65, p. 171--cf. also pp. 176-177, 202, 221-222), and Allport (3, p. 76).

As one married graduate student explained simply, when asked how marriage affected his work: "It *unifies* a man."

Cf., however, Note 18, *supra*.

selves and for the integrity of society. From this point of view Lindsey's (65, p. v) formulation: "legal marriage, with legalized birth control, and with the right to divorce by mutual consent for childless couples, usually without payment of alimony" has much to recommend it. (This formulation, it will be noted, does not commit either individuals or society to the expectation of generally transitory unions.) The other essential thing is that the individuals concerned have some understanding of marriage. This means a sound knowledge of sex; but it means also an understanding of marriage as a relation and as an art whose satisfactions and responsibilities include much more than sex. It means some knowledge of the ground covered by the Binkleys' (5) book, for example.⁴

Emphatically, the findings of the present study provide no apology for license. The psychology of restraint and expression, of "repression" and "catharsis," is very complex, and has scarcely been touched upon here. That perpetual hunger leads to a morbid interest in hunger's satisfaction is clear enough; but that unregulated and egoistic gratification of appetite prevents morbidity does not follow at all. One of the most difficult types of patient with which the psychotherapist has to deal is the individual who knows no more than his immediate self-interest, who has no perspective of values, and who comprehends no relation of himself to the social order. People who feel "emancipated"

⁴Interesting in the same connection is the Binkleys' discussion of romance (6). Cf. also Dell (17, pp. 330 ff., 361 ff.). Exner (28) is excellent on the sexual side. Harris (43a) develops the idea of personal relationship.

enough to enter freely upon sex experimentation, with the result that they find themselves ensnared in various sorts of dissatisfaction, are significant cases of failure to *organized* life.

Professor David Camp Rogers, who as a psychologist has been consulted by persons of various ages about emotional and social adjustments, writes:

"It is a unique characteristic of the human race that in this species sex excitability and the capacity for sex activity are present almost continuously after maturity and are prolonged considerably beyond the years of child-bearing. It is improbable that a feature so elaborate and so strongly established can have developed except through connection with some important biological advantage. The general advantage in this case is evidently related to the prolongation in the human race of the period during which offspring are dependent on parents for food, protection, and training. The intense and pleasurable emotions of sex tend to develop and perpetuate an attachment between two mating individuals and to reenforce the motivation for work done and sacrifices incurred by each in connection with the other and with their family group. Through the

⁴⁰Cf. Dell (17, pp. 77-80).

Hamilton has reported, somewhere, several interesting examples of this sort of unhappiness. Other cases are described by Lindsey and Evans (65, pp. 36-42). Cf., similarly, Normand (85); Mayo (74, pp. 422-423); and Lippmann (66, pp. 302 ff.). We have to remember too that "the difficulties in adjustment to lack of affection and to the upsetting effects of the sex drive at its physiological level may be occasioned more by lack of ability to assign relative values, to judge fairly one's differences in attractiveness, equipment, behavior, and opportunity, than by limitations of actual emotional and physiological needs" (Preston, 92, p. 756).

entire period of history, so I infer, sex emotion, operating in family relationships, has been one of the great factors in the work carried out by each generation for the next, and in group ambition toward progress.

"I have personally deplored the part that psychologists and sociologists have played, in reviving as features of an avowedly scientific point of view (though it is unsupported by new evidence), the to me fallacious *sophistries of Greek thinkers* which hold that since every purpose has certain relations to the individual mind no purpose is more altruistic than any other, and that since pleasures and displeasures have a part in the development and consequences of all purposes, all purposes are in an entirely equal degree purposes aimed at the achievement of pleasure or avoidance of displeasure. I have also regretted the part these same groups have taken in contributing to the more specific popular idea that sex restrictions are mostly unreasoned taboos which should not be allowed by intelligent people to interfere with gratification for strong sex impulses. To me the experiment in assuming freedom for sex gratification apart from attachments intended as permanent, which many in the present generation are carrying on, seems on the whole an extravagant and foolish one. . . .

"It is my strong conviction that a considerable number of those who have taken this new liberty have gotten into more emotional difficulties than they have escaped, and that there has been already a large loss for social motivation and general happiness resulting from this change in customs."¹⁶

¹⁶Personally communicated. Cf. similarly Exner (28, pp. 200 ff.).

Human nature is not set forth fully by psychoanalysis, nor by this or that extreme "school of psychology," alone; and the findings of general psychology run in no way contrary to the conclusion of the ethicists that life is a complexity of interests, and that living involves the integration of these interests, not the satisfaction of some through the destruction of others. Thus, although the data presented here indicate that the enforced celibacy of youth represents, in itself, a decrease rather than an increase of life, this decrease may be necessary, under present social conditions, to avoid greater forms of decrease. As Everett (27, p. 329) says, "I cannot have the experience of being a law-abiding citizen and a thief, a servant of ideal causes and a pander to vice, a lover of enlightenment and an obscurantist. And should I attempt to experience all these modes of life in succession, there are grave, not to say insuperable, obstacles in effecting a transition from one to the other. It is also to be remembered that the deliberate choice not to have a given experience, is itself an experience - an experience which, for the total meaning of life, may be one of the best and richest."

The increasing emancipation from taboos of unreason demands at once a wise conservatism in practice and a deeper understanding of good and evil. This implies an appreciation of scientific ethics as a human enterprise of the first importance; an enterprise the spirit of which appears in Democritus' saying that "an evil and foolish and intemperate and irreligious life should not be called a bad life, but rather dying long drawn out."

It is the task of the ethicist to build, from the results of all the human sciences and arts, formulae for intelligent living. The worker in any branch of study must present his data and the conclusions they suggest, recognizing, in turn, the contributions from other sources. One general principle, however, may be urged, coming as it does from philosophy, psychology, psychiatry, and mental hygiene alike. It is that knowledge, knowledge of individual and social facts, is essential for both individual and social adjustments. To this ancient principle the present writer subscribes. Apparently its acceptance is growing in our times. We may hope that search for knowledge will mean the perfecting of theory as well as of fact, in the field of sex as in other fields, always with a view to life as a whole.

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ÉTUDE CRITIQUE DE LA SUBLIMATION CHEZ LES MÂLES: UNE ÉTUDE DE QUARANTE HOMMES SUPÉRIEURS NON MARIÉS

(Résumé)

Pour tester la théorie de sublimation chez les mâles, l'investigateur a choisi quarante hommes non mariés lesquels ont été supérieurs en les hommes les plus supérieurs des principales universités et écoles supérieures américaines; des hommes qui ont été aussi assez forts en très forts en sports; qui se sont beaucoup intéressés à l'esthétique et dont plusieurs ont accompli quelque chose dans ce domaine; et qui ont été respectés et autres des hommes et des femmes moralement et socialement. On a abordé ces sujets au moyen de la conversation ordinaire et de l'étude du problème. Plusieurs années plus tard on leur a envoyé un questionnaire par le courrier. Dans ce questionnaire sinon auparavant, chaque sujet a donné un rapport franc de sa vie sexuelle, si l'on peut juger ceci par la manière, l'attitude subséquente, et l'évidence interne des données. On a obtenu aussi des rapports introspectifs et des programmes sexuels quantitatifs. En outre, l'investigateur a fait une estimation du fonctionnement intellectuel, athlétique, esthétique et sociale de chaque homme une estimation non précise, mais sujette un peu aux faits objectifs, et suppose être adéquate pour n'importe quelles grandes corrélations avec la sublimation.

Les données montrent une périodicité marquée, avec un échappement sexuel direct de quelque forme dans tous les cas. La forme de l'échappement a été, chez 19 pour cent des sujets, des émissions nocturnes ou "rêves"; chez 15 pour cent, des caresses érotiques ou "attouchements tendres" au point d'orgasme immédiat ou pendant le sommeil de la nuit suivante; chez 63 pour cent, la masturbation; chez 8 pour cent, des prostituées; et chez 13 pour cent, des femmes autres que prostituées. La plupart de ceux dont le seul échappement évident a été des émissions nocturnes ont été dans le groupe le plus jeune (21-25 ans), et aucun n'ont été dans le groupe le plus âgé (32-38 ans). On considère les diverses formes de l'ajustement en quelque détail. Le petit nombre de cas inclus dans l'étude ne montrent pas de relation significative entre le type de l'intérêt professionnel et celui de l'échappement sexuel; les estimations de la supériorité des hommes n'ont pas de corrélations inverses avec la manière directe de l'échappement sexuel; et le sexe et la vigueur générale semblent associés plutôt qu'au contraire.

On inclut un rapport comparatif bien que non précisément comparable sur environ trois cents moines et prêtres, obtenu de leur directeur spirituel.

L'amour sexuel semble être une combinaison d'éléments ou de forces qui peuvent fonctionner de diverses manières. Quand on examine la "sublimation," elle semble se réduire à un groupe de processus: un changement limité de l'activité; une réintégration et un réconditionnement des composants émotifs; l'échappement des attitudes intentionnelles ou délibérées au moyen de semblables situations volitives; la diversion de l'attention pour éviter les excitants habituels de toute impulsion non désirée; l'établissement des inhibitions; la croissance du tonus hédonique et avec cela l'intégration de l'organisme, comme résultat de la satisfaction esthétique, de la stimulation sociale, et du succès personnel; et l'élimination des conflits, autant que possible, au moyen des suggestions, des habitudes, et des inquiétudes qui viennent d'activités nouvelles et d'intérêts nouveaux.

Ces données et ces conclusions ont des limitations évidentes. On ne propose ici aucune résolution parfaite du problème sexuel; bien que le mariage

à un âge pas trop avancé pour être la meilleure et compris comme il le faut. La vie exige l'intégration de connaissances et d'intérêts avec l'intelligence morale.

TAYLOR

EINE KRITIK DER SUBLIMIERUNG BEI MÄNNERN: EINE UNTERSUCHUNG AN VIERZIG HOCHBELEHENDEN UNVERHEIRATETEN MÄNNERN

(Rezension)

Zur Prüfung der Theorie der Sublimierung bei Männern wählte der Forscher vierzig unverheiratete Männer die in ihren Klassen in den hervorragenden amerikanischen Universitäten oder Berufsschulen (professionals) (eher) sehr hoch oder am höchsten standen; die auch im Sport mittelmäßig bis sehr gut begabt waren; die wichtige ethische Interessen und in vielen Fällen Begabungen erwiesen; und die in ethischer und sozialer Beziehung von Männern und Frauen hochachtet und beliebt waren. Man fing in der Untersuchung mit gewöhnlichem Gespräch und mit Darlegung der Aufgabe an. Einige Jahre später fuhr man brieflich mit der Untersuchung fort. Im Lauf der brieflichen Nachforschung, wenn nicht früher, um nach Weiser, späterer Stellungnahme, und innerem Beweis (intuitual) evidences aus den Befunden zu urteilen, erstattete jede Versuchsperson aufrichtig Bericht über ihr Geschlechtsleben. Es wurden auch einige Selbstbetrachtungen (introspective reports) und quantitative Geschlechtsstatistikenprogramme (sex schedules) erhalten. Ferner ordnete der Versuchsleiter rangmäßig die intellektuelle, athletische, ethische, und soziale Tätigkeit jeder Versuchsperson. Die Anwendung (rating) war natürlich nur approximativ; sie konnte sich aber bis zu einem gewissen Grade nach objektiven Tatsachen regeln, und war zu erlangen grossen Korrelationen mit dem Grade der Sublimierung wahrscheinlich genügend.

Die Befunde wiesen auf eine ausgeprägte Periodizität hin; und in jedem Falle gab es irgend eine direkte sexuelle Ausdrucksweise (outlet). Die Ausdrucksform war bei 18% der Versuchspersonen nächtliche Ausflüsse oder "Traume" bei 15% erotisches Liebkosen oder halscheln ("spooning") bis zur Hervorbringung des Orgasmus, sofort oder im Laufe des Schlafes der nachfolgenden Nacht; bei 63% Masturbation; bei 8% Prostituierte, und bei 13% nicht-prostituierende Frauen. Die Mehrzahl derer, deren einzelne direkt sexuelle Ausdrucksweise aus nächtlichen Ausflüssen bestand fielen in die jüngste Gruppe (Alter 21 bis 25 Jahren), und keiner gehörte der ältesten Gruppe an (32-38 Jahre). Die verschiedenen Formen der Anpassung werden ziemlich umständlich besprochen. Die geringe Zahl der Versuchspersonen ergab keine bedeutende Beziehung zwischen der Art der beruflichen Interessen einerseits und der sexuellen Ausdrucksweise andererseits; die Rangordnungen der Männer in Bezug auf Überlegenheit (superiority) erwiesen keine umgekehrte (inverse) Korrelation mit der Direktheit der sexuellen Ausdrucksweise; die sexuelle und die allgemeine Kraft (general vigor) scheinen eher zusammenzugehören als einander entgegengesetzt zu sein.

Ein vergleichender, obwohl nicht gerade vergleichbarer, Bericht über etwa 300 Mönche und Priester, der von ihrem Beichtveater erhalten wurde, wird in der gegenwärtigen Untersuchung mitberücksichtigt.

Die sexuelle Liebe scheint in Verbindung von Elementen oder Kräften zu sein, die auf verschiedene Weisen funktionieren können. Die "Sublimierung" scheint sich nach der Untersuchung auf eine Sammlung von Vorgängen zurückzuführen zu lassen: eine begrenzte Verschiebung (limited shift) der Tätigkeit; Wiederintegrierung und Wiederbedingung affektiver Bestandteile (reintegration and reconditioning of emotional components); Freilassung absichtlicher-oder Willenseinstellungen durch ähnliche Willensgelegenheiten (volitional situations); Ablenkung der Aufmerksamkeit um die gewöhnlichen Reizungen irgend eines ungewünschten Antriebes zu vermeiden; Errichtung von Hemmungen; Steigerung des hedonischen Tonus und damit der Integrierung des Organismus infolge der ästhetischen Befriedigung, der sozialen Ausspannung, und des persönlichen Erfolges; und die Fortschaffung von Konflikten, so weit wie möglich, durch Suggestionen, Gewohnheiten, und Einsichten die aus neuen Tätigkeiten und neuen Interessen hervorspringen.

Diese Befunde und Folgerungen können natürlich nur einen beschränkten Wert haben. Es wird hier keine vollkommene Lösung des Geschlechtsproblems vorgeschlagen, obwohl die frühe Ehe, richtig verstanden, vielleicht am meisten helfen würde. Das Leben verlangt Integrierung (Zusammenwirkung) der Kenntnisse und der Interessen mit ethischer Einsicht.

TAYLOR

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Child Behavior, Animal Behavior,
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GENETIC PSYCHOLOGY MONOGRAPHS

Child Behavior, Animal Behavior,
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A STUDY OF THE NATURE, MEASURE- MENT, AND DETERMINATION OF HAND PREFERENCE*

From the University of Chicago

By

HELEN LOIS KOCH ET AL¹

*Recommended for publication by Harvey A. Carr, accepted by Carl Murchison of the Editorial Board, and received in the Editorial Office, October 2, 1931.

¹The data for the study were gathered in 1928 when the author was at the University of Texas and are a contribution of the laboratory of the Department of Educational Psychology. Evelyn Carrington, Amanda Herring, Ruth Reed, and Will Rivers Shaw helped in planning the experiment and gave the tests. Rosemary Walling assisted in the statistical manipulation of the data.

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THE PROBLEM AND PROCEDURE

Introduction. Until relatively recently the problem of the determinants of hand preference has been sketched rather simply. A twofold classification of individuals—i.e., into the right- and the left-handed—or a threefold one which included an intermediate group, the ambidextrous, was considered adequate, while such categories of determinants as the hereditary and environmental were frequently viewed as entities. Recent studies, however, such as those of Downey (5), Heintzen (7), and Ojemann (11, 12, 13) have already indicated that there are kinds and degrees of preference. Conflicting findings suggest also that the large categories of alleged determinants designated as experiential, or environmental, and hereditary apparently need further exploration and probably division, if our knowledge is to be advanced very far. The effect of method of measurement upon the pattern of the results is still another issue that has come to the fore and with it the question of what is implied by the term, "preference."

The Problems. The present study has attempted to approach some of these problems by noting the manual choices in a large number and variety of standardized situations of a group of about 200 college students. It has had among its specific concerns such questions as: (1) the form of the distribution of hand-preference scores variously obtained; (2) the correlation between

indices of handedness based upon different types of activities; (3) the relative representativeness, as far as manual behavior at large is concerned, of performance in certain specific situations; (4) the divergences with respect to degree and pattern of hand preference shown among groups of individuals differing in sex, college major, family, instruction, accidents to the hands, speech difficulties, and side preference exhibited among certain bilaterally-placed body members other than the hands; (5) the relation between various estimates of hand preference and measures of factors alleged by one or another author to be major determinants of manual choice; (6) the consistency in various tasks of the choice with respect to hand; and (7) the feasibility of substituting for a performance test a questionnaire covering the same tasks as the former, i.e., the reliability and validity of a questionnaire. Comparisons have been made between hand-preference scores based upon activities of different types among which are those differing: (1) in the degree to which it is probable that formal instruction regarding the manual member to be used has played a part in their development; (2) in the equality or inequality of opportunity offered each hand for playing the dominant rôle; (3) in the amount and kind of simultaneous activity occurring in the two hands; and (4) in the degree to which correlation exists with preference trends exhibited in groups of activities.

Subjects. The subjects employed in the major part of the study were 201 undergraduate students registered at the University of Texas in 1928. These ranged in age and major field as shown in Table 1. With the

exception of 43 pairs of sibs, the S's were selected more or less at random from the undergraduate body, in that all of the students in certain courses in education and psychology were enrolled in the experiment. The education courses probably attract a more varied assortment of the women of the campus than do any courses other than the English. Some introductory courses in business psychology were chosen to furnish us S's not only because their personnel is largely male and because these students are representative of rather diverse occupational interests, but also because the course is one of a very narrow group from which all university students are required to elect one. Although, as is clear, we made an effort to sample widely the student body, we now feel that a larger percentage of science students, as well as a substantial number of individuals representing groups as diverse as musicians and engineers, would have contributed to the study.

Administering the Tests. The students knew nothing of the details of our objectives in the experiment other than that it dealt with the problem of hand preference. Some were, of course, hand-conscious while they were performing; but this difficulty was reduced to a minimum by requiring the S's to proceed very quickly through the series of 105 manipulations. The fact that, after the general procedure and the task of recording had become more or less routinized, the performance of the 105 tasks did not take more than half an hour attests to the lack of opportunity for any great amount of meditation on the matter of choice of hand.

Experimenters. Four experimenters collected the

data. Before the major experiment began, these were trained for uniformity in procedure by being given specific written directions concerning each activity and by practicing on each other under the author's supervision until all but very minor differences in method were eliminated. The experimenters were, with one exception, graduate students in educational psychology and were familiar with the necessity for accuracy and uniformity.

Selection of the Tasks. The tasks were selected with a number of considerations in mind. (1) We wished to sample a wide range of familiar manipulations as well as (2) to include most of the tasks employed by one or another of previous experimenters as diagnostic of hand preference. (3) Since manual activities may involve essentially one or both hands, it seemed desirable to investigate hand preferences in both of these types of situation. (4) As we were concerned with the problem of the effect of instruction on manual preference, we selected some activities in which the S's were likely to have received specific instruction and some in which they were not. (5) Surmising that degrees of hand preference might be more readily revealed by the consistency with which a given hand was used in the face of certain handicaps than by the number of times a given hand was preferred when both were offered equal opportunity for playing the dominant rôle, we arranged for some tasks which presented a position handicap with respect to each hand as well as some in which the spatial determinants as far as the hand choices were concerned were apparently equal.

The Nature of the Tasks. The manipulations each S performed and the classification of activities we adopted are described in the questionnaire on pages 127-135, which, like the performance tests, was given to all S's. In this latter the S's were merely told to perform all the operations about which they were questioned in the questionnaire. In Part I, for instance, the following directions for the various items were used. "Tie this sash around your waist, making a double bow-knot in front. 2. Deal these cards into 4 piles. 3. Set this mouse-trap. 4. Pretend to play this ukulele. 5. Catch this ball with both hands, covering it with one. 6. Pretend to shoot this arrow. 7. Pretend to shoot this gun. 8. Strike this ball with this club. 9. Try to strike this ball with this bat. 10. Tie this tie in a fore-in-hand."

Labels. The series included in Part I we shall designate, for convenience, "bimanual taught"; in Part II, as "bimanual untaught"; in Part III, as "unimanual taught"; in Part IVA, as "unimanual untaught—equal opportunity"; in Part IVB, "unimanual untaught—handicap offered"; and in Part V, as "side preference."

Scoring. The score on any group or combination of groups of tasks will be given in percentage terms, in order to facilitate comparisons, and in terms of the right bias. In other words, a score of 70 on the bimanual untaught activities means that in 7 of the 10 activities the right hand performed presumably the more skillful manipulation. A similar score on the unimanual taught activities means that in 70% of the tasks the right hand was chosen to do the work.

GENERAL QUESTIONS

PART A

1. Name Date
 Sex Age Year in College
 Major Class

Encircle the word or figure in each of the following questions which, in your case, best answers the question. If answers are not provided for checking, fill in the blanks.

2. At what age did you learn to talk—i.e., have a vocabulary of three words? Months: 6 7 8 9 10 11 12 13 14 15 16 17 18 19.
 If you learned to talk at an age later than 19 months indicate the month here.
 If you have never been told when you learned to talk or that you were slow about it, put a cross here.
3. Have you ever had any of the following speech difficulties? Lalling, stammering, stuttering, lisping, indistinct speech, aphasia, hesitation
 Give the age of onset and cessation of the difficulty.
4. Were you ever left-handed? YES NO
 If so, state at what age.
 How long did this last?
5. Have you had to be trained definitely to use your right hand?
 YES NO
6. Have you ever had any accident to your hands or arms that prevented you from using them for two weeks or more?
 YES NO
7. Are you confused frequently in distinguishing right from left in the situations listed below?
 a. Military or gymnastic drill YES NO
 b. Waiting on table YES NO
 c. Driving a car YES NO
8. Encircle either *a*, *b*, or *c* below to indicate how you learned to distinguish your right hand from your left. If your method was different from those listed, describe it in the blank *d*.
 a. Direct apprehension of difference
 b. Kinnaesthetic cue (hand that writes, holds spoon, throws, is offered in shaking hands, etc.)
 c. Arbitrary and visual cues (warts, ring, scar, way a house or room faces, etc.)
 d.

9. Which of your hands do you believe is the stronger?
 RIGHT' LEFT'
10. Have you ever had any eye disorders? YES NO
 If so, what kind?
 In which eye?
 How long did this last?
11. Did you at any time in your life write or tend to write mirror-script?
 YES NO
12. a. Are there any left-handed persons in your immediate family?
 YES NO
 If so, encircle the word indicating the relationship; and in the case of brothers or sisters, indicate the number.
 Father, mother, brother sister
- b. If you have any left-handed relatives of the degree listed below, encircle the degree of relationship in which this is found and indicate after each item the number of cases.
 Maternal grandmother Maternal grandfather
 Maternal aunts . . . Maternal uncles . . . Maternal first cousins
 Paternal grandmother Paternal grandfather
 Paternal aunts Paternal uncles Paternal first cousins

PART I

Put a circle around the *R* or *L* (ONE ONLY) found in the right-hand margin following each item to indicate whether you prefer to use your right or left hand in the activity described. It is understood, unless otherwise specified in the description of an activity, that the object which you are to pick up before manipulating it has been placed directly in front of you and equidistant from both hands.

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|---|---|---|
| 1. In tying a sash around your waist (a double bow-knot tied in front), which hand does most of the manipulating? | R | L |
| 2. With which hand do you distribute cards when dealing? | R | L |
| 3. When setting a snap mouse-trap, with which hand do you prefer to pull back the spring? | R | L |
| 4. When playing a ukulele, with which hand do you prefer to strike the strings? | R | L |
| 5. When catching a ball with both hands, which hand do you use to cover the ball? | R | L |

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| 6. When shooting with a bow and arrow, with which hand do you prefer to pull back the string? | R | L |
| 7. When firing a rifle, with which hand do you manipulate the trigger? | R | L |
| 8. When golfing, which hand do you have nearer that end of the club which strikes the ball? | R | L |
| 9. When batting a baseball, which hand do you have nearer that end of the bat which strikes the ball? | R | L |
| 10. When tying a slip (fore-in-hand) tie around your neck, which hand does most of the manipulating? | R | L |

PART II

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|---|---|---|
| 1. When sweeping, which hand do you prefer to have nearer the upper end of the broom? | R | L |
| 2. When mopping, which hand do you prefer to have nearer the upper end of the mop? | R | L |
| 3. When boring a hole with a brace and bit, which hand guides the metal handle? | R | L |
| 4. When using two hands to raise a large window, which hand does the most work? | R | L |
| 5. When opening an umbrella which you are holding, with which hand do you prefer to manipulate the clasp? | R | L |
| 6. When rubbing clothes which you are washing, which hand does most of the work? | R | L |
| 7. When running a tape through the hem of a laundry bag, which hand pushes the bodkin? | R | L |
| 8. When fitting a square of paper into a slightly larger square ruled off on a sheet of paper, which hand does most of the adjusting? | R | L |
| 9. When you clasp your hands, which thumb is on top? | R | L |
| 10. When applauding, which hand is uppermost? | R | L |

PART III

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|--|---|---|
| 1. When lifting meat to your mouth after cutting it with a knife, in which hand do you prefer to use the fork? | R | L |
| 2. With which hand do you prefer to write? | R | L |
| Write "Four score and seven" with your left hand. | | |
| | | |
| Now write the same with your right hand. | | |
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| 3. If both hands are free, with which do you prefer to wave good-bye? | R | L |
| 4. In which hand do you prefer to hold the needle when sewing? | R | L |
| 5. When you are threading a needle, which hand does most of the adjusting? | R | L |
| 6. In which hand do you prefer to hold a tennis racket when playing tennis? | R | L |
| 7. Which hand do you extend when you shake hands? | R | L |
| 8. If both hands are free, with which hand do you prefer to hold the spoon when eating soup? | R | L |
| 9. With which hand do you prefer to hold a wire egg-beater when beating eggs? | R | L |
| 10. With which hand do you prefer to throw a ball? | R | L |
| 11. When playing jacks, with which hand do you prefer to play? | R | L |
| 12. With which hand do you prefer to throw a spinning top which you have wound with a string? | R | L |
| 13. With which hand do you prefer to shoot marbles? | R | L |
| 14. With which hand do you prefer to hold the spreader when buttering bread? | R | L |
| 15. With which hand do you prefer to receive food passed to you from your left? | R | L |
| 16. When cutting a piece of paper, in which hand do you prefer to hold the scissors? | R | L |
| 17. When holding a book, with which hand do you prefer to turn the pages? | R | L |
| 18. When drinking water from a glass, with which hand do you prefer to hold the glass? | R | L |
| 19. With which hand do you prefer to turn a faucet? | R | L |
| 20. With which hand do you prefer to place the stamp on an envelope? | R | L |

PART IVA

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|--|---|---|
| 1. When driving a nail into a flat board that is directly in front of you, in which hand do you prefer to hold the hammer? | R | L |
| 2. In which hand do you prefer the comb when you comb your hair? | R | L |

3. In which hand do you prefer to hold the toothbrush when you brush your teeth? R L
4. In which hand do you prefer to hold the brush when you are brushing your clothes? R L
5. In which hand do you prefer to hold a mirror when looking at yourself? R L
6. When stroking your chin, which hand do you prefer to use if both hands are unoccupied? R L
7. With which hand do you prefer to push your hair back from your forehead, if both hands are free? R L
8. On which hand or in which pocket do you wear your watch? R L
9. With which hand do you prefer to take hold of a pitcher standing with its handle to your right when you are to pour cream on your cereal?
With its handle to your left? R L
10. With which hand do you prefer to hold the knife when you are peeling an apple? R L
11. When washing dishes, with which hand do you prefer to hold the dishrag? R L
12. With which hand do you prefer to pull a cork from a bottle? R L
13. With which hand do you prefer to strike a match on the bottom of your shoe? R L
14. When raising your hand in class, which hand do you tend to raise?
If you do this for any of the following reasons, check the reason: Prettiest hand, ring-hand, unscarred or uninjured hand. R L
15. In carrying books when both hands are at your service, with which hand do you prefer to hold the books? R L
16. In carrying books when you have an umbrella in one hand, with which hand do you prefer to hold the umbrella? R L
17. If a handkerchief is dropped directly in front of you, with which hand do you prefer to pick it up? R L
18. When you blow your nose, with which hand do you prefer to hold the handkerchief? R L
19. With which hand do you prefer to turn a key in a lock if both hands are free? R L

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| 20. With which hand do you prefer to put pegs into a peg-board? | R | L |
| 21. With which hand do you prefer to drop letters into a slot in a small mail box? | R | L |
| 22. With which hand do you prefer to shift the weights on the scale when you are weighing yourself? | R | L |
| 23. With which hand do you prefer to pull down a curtain? | R | L |
| 24. With which hand do you prefer to wind a watch? | R | L |
| 25. When brushing trash into a dust pan, in which hand do you prefer to hold the brush? | R | L |

PART IVB

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|---|---|---|
| 1. On coming into a room which has a light switch for a central light at your right, with which hand do you prefer to turn the switch? | R | L |
| On leaving the same room, which hand do you prefer to use for turning off the light? | R | L |
| 2. With which hand do you prefer to close a door that opens to your left as you enter a room? | R | L |
| 3. With which hand do you prefer to turn a door-knob which is at your right? | R | L |
| At your left? | R | L |
| 4. If both hands are free, with which hand do you prefer to pull toward you a light-weight chair which is facing you and at your right? | R | L |
| At your left? | R | L |
| 5. With which hand do you prefer to reach for a book placed at your right? | R | L |
| At your left? | R | L |
| 6. With which hand do you prefer to pull open a drawer which is at your right? | R | L |
| At your left? | R | L |
| 7. With which hand do you prefer to grasp an object moving in a plane at your right? | R | L |
| At your left? | R | L |
| 8. With which hand do you prefer to hold a glass to receive water if the person who pours it is at your right? | R | L |
| At your left? | R | L |

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| 9. If both hands are free, with which hand do you prefer to insert a straw into a bottle if the straw is offered to you from the right? | R | L |
| From the left? | R | L |
| 10. With which hand do you prefer to lift to your left a packed suitcase which is resting at your right? | R | L |
| To lift it to your right when it is resting at your left? | R | L |
| 11. If both hands are free, with which hand do you prefer to carry a parasol to shield yourself from the sun or a bright light which is coming from your right? | R | L |
| From your left? | R | L |
| 12. If both hands are free, with which hand do you prefer to hold a washrag when you wash your right cheek? | R | L |
| Your left cheek? | R | L |
| 13. With which hand do you prefer to fan a person sitting at your right? | R | L |
| At your left? | R | L |
| 14. When the buttons on a coat you are wearing are to the left and near the neck and you are given one hand to use in buttoning them, which hand do you prefer? | R | L |
| When the buttons are to the right and near the neck, which hand do you prefer? | R | L |
| When the buttons are to the left and near the waist, which hand do you prefer? | R | L |
| When the buttons are to the right and near the waist, which hand do you prefer? | R | L |
| 15. With which hand do you prefer to whisk a thread from the right shoulder of your coat? | R | L |
| From the left shoulder? | R | L |
| 16. With which hand would you prefer to remove a particle of paper from the right side of your head while looking in a wall mirror? | R | L |
| From the left side? | R | L |
| 17. If both hands are free, with which hand do you prefer to shade your eyes from a bright light that is coming from your right? | R | L |
| From your left? | R | L |

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|-----|--|---|---|
| 18. | With which hand do you prefer to pull off your right shoe when you are sitting down? | R | L |
| | Your left shoe? | R | L |
| 19. | With which hand do you prefer to wipe your right eye when it is tearing? | R | L |
| 20. | With which hand do you prefer to place a clothes-pin on the left edge of a towel hanging on a clothes-line? | R | L |
| | On the right edge? | R | L |
| 21. | If you spilled a drop of ink on your paper while writing with your pen, in which hand would you hold a small piece of blotter to absorb the ink if only one hand is to be used on the blotter? | R | L |
| 22. | If you have made a mistake while writing on the blackboard, with which hand do you prefer to erase it? | R | L |
| 23. | When fighting, with which hand do you prefer to ward off blows directed toward your right? | R | L |
| | Toward your left? | R | L |
| 24. | When you have a bucket of water in one hand, with which hand do you prefer to hold on to the rungs of a stepladder as you ascend it? | R | L |
| | As you descend it? | R | L |
| 25. | When holding one end of a rope and turning it for someone to jump, with which hand do you prefer to throw the rope when throwing toward your right? | R | L |
| | Toward your left? | R | L |

PART V

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|----|---|---|---|
| 1. | Over which shoulder do you hold the bat before striking? | R | L |
| 2. | When pirouetting, in which direction do you tend to turn? | R | L |
| 3. | a. Do you prefer your left eye or your right eye for sighting? | R | L |
| | Do you have no preference? YES NO | | |
| | b. With which eye do you usually sight when using a microscope? | R | L |
| | Can you use your non-preferred eye in a microscope? YES NO | | |
| | c. Try the following experiment: Use a small | | |

finger ring, holding it at arm's length, and encircling a small object a few yards away. Keep the same head and eye position throughout the experiment. Close your right eye. Check what happens.

- (1) No change
- (2) Ring moves to right of object
- (3) Ring moves to left of object

Re-focus. Close your left eye. Check what happens.

- (1) No change
- (2) Ring moves to right of object
- (3) Ring moves to left of object

Repeat this until you are confident of the accuracy of your report.

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|---|---|---|
| 4. On which foot can you balance your body's weight the better? | R | L |
| 5. On which side do you prefer to sleep? | R | L |
| 6. When sitting with legs crossed, which is usually the uppermost leg? | R | L |
| 7. Against which shoulder do you prefer to hold a gun while firing? | R | L |
| 8. If you are told to roll your tongue, in which direction do you roll it? | R | L |
| 9. When cracking a peanut with your teeth, which jaw do you prefer to use? | R | L |
| 10. If you were told to listen to the ticking of a watch which was held behind you at such a distance that you could barely hear it, which ear would you prefer to turn toward the watch in order to hear more effectively? | R | L |

General Criticism of the Tasks. The tasks included in Parts I, II, III, and IVA, with two minor exceptions, i.e., Part III, Item 15 and Part IVA, Item 9, when they involved the handling of an object, were so planned as to require the S to pick up the object himself after he had been placed squarely before it by the E. This method of equating opportunity for

the two hands is not irreproachable, since no very minute measurements were made and no effort was exerted to control *in great detail* the set of the body. Especially conspicuous, moreover, was our lack of control in Part I, Item 3, where it was difficult with our skill in throwing a ball to direct it exactly to the middle of the S; in Part IVA, Item 22, where, although the weights were placed in a central space, the direction of their movement was a function in part of the weight of the person on the scales; and in Part IVA, Item 7, where it was apparent that each S did not reach when the approaching object attained a particular distance from him.

Criticism of the Tasks Involving a Position Handicap. The tasks included in Part IVB, as has been indicated, are those designed to offer first a position handicap and then a position advantage to each hand. The position factor we attempted to keep reasonably constant with respect to the objects involved in the adjustment; but it is questionable whether the exertion involved in a reach covering a certain absolute distance on the floor was not considerably at variance for the tall and short or for the long- and short-armed persons. We noted, moreover, as the experiment progressed, that the degree of inconvenience could not be inferred directly from the distance between the S and the initial placement of the object. Some S's seemed to prefer the crossed-arm technique.

A study of the items in Part IVB showed that of the 19 adjustments in which we had assumed the right hand to be favored in position, 4.90 times on the aver-

age (sigma dist. = 2.37) the right hand was used and 4.10 times, the left (sigma dist. = 2.37). When the position advantage was supposedly with the left hand, the right hand was employed 11.22 times on the average (sigma dist. = 3.44) and the left, 7.78 times (sigma dist. = 3.44). These findings and those of Table 12 suggest that in a few cases at least—Items 15a, 18a, 21a, 24a—we were probably incorrect in our diagnosis of what constituted a handicap or advantage.

Bimanual vs. Unimanual. Comment is in order at this point concerning another debatable point in our procedure, i.e., our classification of tasks into unimanual and bimanual. This we recognize to be arbitrary, since all activities are, in a sense, bimanual. The so-called inactive hand is always doing something and probably has more influence upon the manual Gestalt than we suspect. For purposes of study, however, we designated an activity as bimanual if both hands were involved in manipulating the same physical object. It was considered that an activity was unimanual, at least as far as the central object of the adjustment was concerned, when one hand was occupied with nothing in particular or with another object. Of course, in the latter case the scoring for hand preference was based upon the hand employed in the manipulation requiring the most skill.

Difficulty in determining the hand engaged in the most skillful adjustment was occasionally experienced. In brushing trash into a dust pan, for instance, attention was centered on the brush, as we were of the opinion that a strongly right-handed person would

hold the brush in that hand. We did discover, however, that there were a few cases in which the S apparently performed the more delicate coordinations with the object least expected to elicit these. In the case of certain bimanual tasks this difficulty of determining which hand directed the activity was especially troublesome. We question, accordingly, the validity of the procedure which designates arbitrarily as the dominating hand that which is near the active end of the instrument. An intensive study of the broom and mop manipulations conducted at the end of our investigation, for example, revealed that of 48 S's, 29 claimed that the hand farthest from the base of the broom did most of the work, whereas in the case of the mop, 13 out of 48 made such assertions. Similarly, we have observed that those expertly coached in golf insist that the left hand directs the blow, although the right is placed somewhat lower on the handle of the club. While it is true one may question the reliability of the S's opinions and reports, observation of the behavior of the S's provoked faith in their introspections.

In spite of the crudities and difficulties in technique with respect to certain bimanual tasks which we have just discussed, we feel that the general patterns of the bulk of our results are not grossly disfigured. The influence of specific biasing factors we shall attempt to evaluate as we treat our findings in detail.

Taught vs. Untaught. Our placement of specific tasks in the categories of taught and untaught is still another phase of our procedure which may be chal-

lenged. Let it be said that it was not even our hope to discover tasks in which tuition had been received by no S. In the case of those activities to which we shall refer as taught, each of the experimenters could recollect being coached at some time or other with respect to the traditional manual choice or the everyday situation in which the adjustment occurred seemed to be biased in favor of the right hand. Of the series designated as untaught, this was not true. Hence, it seemed reasonable to infer that, while teaching influences were probably not eliminated from the untaught nor always present in the taught, instructional or cultural effects were more emphatic in the latter series than in the former.

Side Preference. Of the validity of some of our measures of side preference in non-manual members, we are inclined to be much more dubious than we are of those of manual preferences, since the former are for the most part based on a single or a limited number of samples of the behavior of the member.

General Personal and Family History. In addition to data concerning eye and hand preference, it seemed well to gather for each S such information as a questionnaire could yield concerning the number and degree of relationship to the S of the left-handed relatives, the S's experience with speech difficulties; incapacitating accidents to eyes, hands, or arms; the amount of coaching regarding choice of hand that had been received; and the ease of identifying right and left. The possible significance of most of this information is obvious.

II

A STATISTICAL STUDY OF THE TESTS

A. PERFORMANCE TEST

Introduction. Before proceeding to a discussion of various relationships involving the measures of preference we have obtained, it seemed well to examine our tools in detail, to question their validity, reliability, internal consistency, etc., and to consider such theoretical issues concerning the nature of handedness as the test results in and of themselves enlighten.

Validity of the Performance Test--General Discussion. As was suggested earlier in the discussion, we may profitably question the connotation of the term "preference." Most authors read into the word the meaning, "preference as determined by difference in the relative skill of the two hands." Some imply the difference to be native; some, native or acquired. Ojemann (11), for instance, in his investigation, afforded both hands the opportunity of performing the same manipulation, their relative skill being determined by some criterion such as speed of execution or quality of product. Strength of preference was then defined in terms of degree of difference in skill. His method has the merit of being in a high degree objective. However, although the generally more skillful hand usually engages in the more difficult phases of a specific adjustment, strength of preference may be conceived more broadly as the expression of many influences, relative skill being only one, though probably

the major class. To view objectively, then, the preference problem and to investigate along with others this frequently implied determinant, relative skill, as well as the problem of the multiple or unitary nature of the latter, seemed to us a desirable procedure.

If preference is an abstraction based upon choice behavior, then the devising of a preference index might well be accomplished by noting in what percentage of a large number of representative manual situations each of the hands was selected to direct the more taxing phases of the coordinations. The task of validating this index, then, would involve merely determining the representativeness of the situations, for, as a basis of the index, actual performances have been viewed. One might make an inventory of the millions of manipulations in which our hands engaged, classify these according to some rational scheme, and then select in appropriate proportions a few activities to represent these classes. Complete validation, of course, would involve checking small samples against much larger ones.

The procedure just outlined is not exactly ours. As for many hours we observed the manual activities of individuals about us, we felt it was futile to attempt to sample them on any frequency basis. Performance seemed so much a function of needs and of the conformation of specific circumstances. Our compromise, then, was to select, with those other considerations in mind which we have already discussed in the section on procedure, 105 common tasks which tap varied interests and experiences.

Correlations—Split-Halves Method. Our group scores we have attempted to validate, in a sense, by comparing each S's scores on the odd items in each activity group with his scores on the even. Although this procedure is not usually looked upon as one of validation, it seems not amiss to so view it here, at least in a measure, since *each task involves a choice* and the range of tasks is large. We may argue that, if the samples of activities agree with each other in regard to what they reveal concerning individuals, this would indicate a fair degree of generalization and stability in preference trends.

The correlations obtained by the split-halves method, as well as those for a test double in length, i.e., the length of the test before splitting it, as estimated by the Spearman-Brown formula, are given in Table 2. These results suggest that the groups of tasks in the uni-manual series, in which the object to be manipulated

TABLE 2
COEFFICIENTS OF RELIABILITY FOR THE FIRST PERFORMANCE TEST
—SPLIT-HALVES METHOD

Type of manipulation	Correlations between odd and even items	Correlations for tests double the length of those used for Column 1	Correlations for tests four times the length of those used for Column 1
Bimanual taught	.693±.025	.819±.017	.900±.009
Bimanual untaught	.535±.034	.696±.029	.822±.015
Unimanual taught	.910±.008	.953±.004	
Unimanual untaught— equal opportunity	.887±.010	.940±.005	
Unimanual untaught— handicap offered	.839±.014	.912±.008	
Total hand preference	.828±.015	.906±.009	

was placed directly in front of the S, measure approximately the same thing. The odd and even items in the section involving the position handicaps and advantages are not quite so well agreed in regard to what they indicate concerning an individual's standing. The bimanual series shows the lowest coefficients.

It is probable that the lower correlations for the bimanual series are due, in the main, to the smaller number of tasks in them. When coefficients for a test 20 items in length—the length of the shortest unimanual series—are estimated by means of the Spearman-Brown formula, the correlations for the two bimanual sections become $+.900$ and $+.822$, respectively. The former coefficient is slightly less than those for the comparable unimanual series. The fact, however, that the coefficients for the bimanual untaught series remain somewhat below the others after the correction for length has been made, may be a result of a difficulty we have already mentioned, namely, that of discovering which hand is directing the operations. It is also not only possible, but even probable, that bimanual behavior, especially the untaught, is a function of a greater variety of determinants than is the unimanual.

Intersection Correlations. The split-halves method compares the results of operations rather similar in type. It will be interesting to study the relationships between such samples of preference behavior as are represented by the five sections of our test. The intersection correlations are given in Table 3; and the first-, second- and third-order partials, in Table 4.

TABLE 3
CORRELATIONS BETWEEN THE SCORES MADE ON THE BASIS OF VARIOUS TYPES OF MANIPULATION—FIRST
PERFORMANCE TEST—CORRELATIONS RAW AND CORRECTED FOR ATTENUATION

	Bimanual untaught Raw Corrected	Unimanual taught Raw Corrected	Unimanual untaught— equal opportunity Raw Corrected	Unimanual untaught— handicap offered Raw Corrected	Hand preference total Raw Corrected
Bimanual taught	.633±.025 .505±.023	.720±.023 .815±.022	.677±.025 .772±.026	.386±.040 .447±.047	.685±.025 .796±.026
Bimanual untaught		.716±.023 .880±.024	.706±.024 .874±.025	.491±.036 .617±.045	.737±.021 .928±.022
Unimanual taught			.881±.010 .931±.009	.545±.033 .585±.035	.886±.010 .970±.012
Unimanual untaught— equal opportunity				.634±.028 .685±.028	.896±.009 .972±.003
Unimanual untaught— handicap offered					.807±.017 .898±.017

These make it clear that the various sections are tapping to a considerable degree the same trait or traits. On the other hand, since (1) the odd-even items correlate to the extent they do; (2) the correlations between two tests separated by an interval of two weeks are relatively high (Table 7); (3) the zero-order intersection correlations range from $+0.386$ to almost $+0.881$ and group themselves mostly between $+0.60$ and $+0.80$ (Table 3); (4) some of the third-order partials still have considerable magnitude (Table 4); and (5) the intersection correlations corrected for attenuation range from $+0.447$ to $+0.931$; it seems that there is much which the various sections do not have in common, rather than that our samples are inadequate or our diagnosis inaccurate.

It is worthy of note that the handicap series correlates least with the others (Table 3). The third-order partials, moreover, show the two bimanual tests to correlate to a considerable degree ($+0.334$) when what is involved in the unimanuals is held constant; and the sections containing the "taught" tasks to correlate to the extent of $.286$, when what is involved in the "untaught" is held constant. The handicap series seems to add least to our total instrument, for partialling out this section affects relatively little the second-order partials (Table 4).

Averages. If our samples of the two types of performance are at all adequate and comparisons are made only between the activities where equal opportunity was presumably offered both hands, it appears that the unimanual activities command a larger per-

centage of right choices and show a lesser variability than do the bimanual, a result which agrees with Ojemann's (12) conclusions arrived at by a radically different procedure from the one we employed. (See Tables 5 and 6.)

TABLE 4
FIRST-, SECOND-, AND THIRD-ORDER PARTIAL CORRELATIONS BETWEEN THE SECTIONS OF THE TEST—FIRST PERFORMANCE TEST

(1 = bimanual taught; 2 = bimanual untaught; 3 = unimanual taught; 4 = unimanual untaught—equal opportunity; and 5 = unimanual untaught—handicap offered)

Zero-order		First-order		Second-order		Third-order	
Coefficient	Value	Coefficient	Value	Coefficient	Value	Coefficient	Value
r_{12}	+.683	$r_{12.3}$	+.345	$r_{12.34}$	+.327	$r_{12.345}$	+.334
		$r_{12.4}$	+.391	$r_{12.45}$	+.401		
		$r_{12.5}$	+.613	$r_{12.35}$	+.352		
r_{13}	+.720	$r_{13.2}$	+.453	$r_{13.24}$	+.276	$r_{13.245}$	+.286
		$r_{13.4}$	+.356	$r_{13.25}$	+.360		
		$r_{13.5}$	+.660	$r_{13.45}$	+.453		
r_{14}	+.677	$r_{14.2}$	+.377	$r_{14.23}$	+.055	$r_{14.235}$	+.089
		$r_{14.3}$	+.131	$r_{14.25}$	+.138		
		$r_{14.5}$	+.746	$r_{14.35}$	+.386		
r_{15}	+.386	$r_{15.2}$	+.080	$r_{15.23}$	—+.076	$r_{15.235}$	—+.084
		$r_{15.3}$	—+.001	$r_{15.24}$	—+.057		
		$r_{15.4}$	—+.076	$r_{15.35}$	—+.116		
r_{23}	+.716	$r_{23.1}$	+.041	$r_{23.14}$	+.162	$r_{23.145}$	+.163
		$r_{23.4}$	+.280	$r_{23.15}$	+.278		
		$r_{23.5}$	+.614	$r_{23.45}$	+.351		
r_{24}	+.706	$r_{24.1}$	+.453	$r_{24.13}$	+.198	$r_{24.135}$	+.163
		$r_{24.3}$	+.227	$r_{24.15}$	+.176		
		$r_{24.5}$	+.586	$r_{24.35}$	+.341		
r_{25}	+.491	$r_{25.1}$	+.337	$r_{25.13}$	+.188	$r_{25.134}$	+.122
		$r_{25.3}$	+.172	$r_{25.14}$	+.094		
		$r_{25.4}$	+.078	$r_{25.15}$	+.118		
r_{34}	+.881	$r_{34.1}$	+.771	$r_{34.12}$	+.713	$r_{34.125}$	+.673
		$r_{34.2}$	+.761	$r_{34.15}$	+.731		
		$r_{34.5}$	+.825	$r_{34.13}$	+.713		
r_{35}	+.545	$r_{35.1}$	+.417	$r_{35.12}$	+.317	$r_{35.124}$	—+.032
		$r_{35.2}$	+.317	$r_{35.14}$	—+.064		
		$r_{35.4}$	+.038	$r_{35.15}$	+.472	$r_{35.125}$	+.370
r_{45}	+.634	$r_{45.1}$	+.549	$r_{45.12}$	—+.001		
		$r_{45.2}$	+.465	$r_{45.14}$	+.364		
		$r_{45.3}$	+.388	$r_{45.15}$	+.392		

TABLE 6

RATIOS OF THE DIFFERENCES BETWEEN THE MEAN SCORES MADE BY THE TOTAL GROUP ON VARIOUS TYPES OF MANIPULATION AND THE PROBABLE ERRORS OF THESE DIFFERENCES—FIRST PERFORMANCE TEST

Types of manipulation compared	<i>P.E._{diff.}</i>	<i>Diff.</i>	<i>P.E._{diff.}</i>
Bimanual taught and bimanual untaught	.615	6.31	10.26
Bimanual taught and unimanual taught	.634	6.93	10.94
Bimanual taught and unimanual untaught— equal opportunity	.666	3.38	5.07
Bimanual taught and unimanual untaught— handicap offered	.813	20.98	25.80
Bimanual untaught and unimanual taught	.851	13.18	15.49
Bimanual untaught and unimanual untaught— equal opportunity	.641	2.93	4.57
Bimanual untaught and unimanual untaught— handicap offered	.787	14.67	18.64
Bimanual total and unimanual total	.516	5.07	9.82
Unimanual taught and unimanual untaught— equal opportunity	.396	10.25	25.86
Unimanual taught and unimanual untaught— handicap offered	.718	27.85	34.82
Unimanual untaught—equal opportunity and unimanual untaught—handicap offered	.613	17.60	28.70

The significance of the difference is not clear. It may mean: (1) that, where a choice seems obvious to the reactor, the right hand tends to be favored, or, conversely, that he is forgetful of his right-handedness in the bimanual tasks and more responsive to convenience; (2) that our criteria for distinguishing the dominating hand in the bimanual activities were not always adequate; or (3) that other body factors are more likely to be influential in bimanual than unimanual tasks.

Our check experiment with the broom lends some support to hypothesis (2); but Ojemann's corroboration of our results by a method different from ours sug-

gests that ineffective procedure is not by any means the total explanation.

The averages in Table 5 also reveal that in the sections labelled "taught" the preference for the right hand is stronger than in those sections labelled "untaught." Instruction, then, does seem to have a noticeable effect upon preference.

Reliability of the Performance Test—Correlation Approach. The stability of hand preference over a period of time, i.e., the reliability of the performance test, we attempted to gauge by giving each S two tests. We, likewise, asked the S's to fill out two questionnaires. The performance and questionnaire tests were alternated. Between the various tests an interval of approximately four weeks occurred. This, it was thought, would be sufficient to permit the desirable forgetting. As the tests proceeded, it became apparent, however, that there was a slight carry-over.

For the major experiment concerned with the question of consistency in performance, it was feasible to use a group of only 50 S's. These constituted all of the members of two classes taking educational psychology and, hence, were selected only to that degree. Two E's, Evelyn Carrington and Will Rivers Shaw, conducted this phase of the investigation, each one caring for the same number (25) of S's in all of the tests. Since the two E's were closely supervised and worked together intimately, we feel confident their procedures were in a high degree similar.

The results of the correlations between the two performance tests are, generally, rather high. (See Table

TABLE 7
CORRELATIONS BETWEEN VARIOUS COMBINATIONS OF PERFORMANCE AND QUESTIONNAIRE TESTS

Types of manipulation	Tests compared				
	Q ₁ P ₁ (201 cases)	Q ₁ P ₂ (50 cases)	Q ₁ P ₃ (50 cases)	P ₁ P ₂ (50 cases)	Q ₁ Q ₂ (50 cases)
Bimanual taught	.798±.017	.829±.030	.880±.021	.950±.010	.915±.015
Bimanual untaught	.715±.024	.788±.037	.870±.023	.870±.022	.879±.021
Bimanual total	.807±.016	.871±.022	.918±.016	.988±.002	.929±.011
Unimanual taught	.941±.005	.982±.003	.974±.005	.981±.003	.986±.002
Unimanual untaught— equal opportunity	.864±.012	.912±.012	.940±.011	.956±.009	.961±.007
Unimanual untaught— handicap offered	.677±.025	.801±.034	.887±.020	.950±.009	.921±.014
Unimanual total	.883±.010	.948±.010	.942±.010	.967±.006	.952±.010
Hand preference total	.870±.011	.898±.021	.962±.007	.925±.014	.966±.006

7, Column 4.) In almost all of its sections our measure exhibits a reliability sufficiently great to justify its use in individual diagnosis. All but one of the sections have reliability coefficients above +.92 and all but two sections, coefficients of +.95 or above. As one might surmise, the activity groups designated "taught" called forth somewhat more consistent performance than did the "untaught." The unimanual and bimanual activities, on the other hand, did not yield grossly different results. If one of these is less reliable for total rankings than the other, it would probably be the bimanual; but differences in the length of the series make any essential dissimilarity seem unlikely. It is noteworthy, also, that the tests involving a position handicap showed about as great reliability as those affording equal opportunity for the selection of the two hands.

Reliability of the Performance Test Item-Com-

parison Approach. Believing that in the face of considerable variability, as far as performance on individual items is concerned, correlations between total scores of various sorts might still be high, we also made a study of the number of items with respect to which the manual choice failed to agree in the two performance tests. Our findings are given in Table 9. It appears that, if one views the tests as a whole, about one-tenth of the hand manipulations were different in the two performances. Among the 20 bimanual tasks, 6.5% of the time, on the average, the choice of hand

TABLE 8

RATIOS OF THE DIFFERENCES* BETWEEN THE CORRELATIONS OBTAINED BETWEEN THE VARIOUS PERFORMANCE AND QUESTIONNAIRE TESTS AND THE PROBABLE ERRORS OF THESE DIFFERENCES

Type of manipulation	Correlations compared						
	Q_1P_1 (201 cases) and Q_1P_1 (50 cases)	Q_1P_1 and P_1P_1	Q_1P_1 and Q_1Q_1	Q_1P_1 and Q_2P_1	Q_2P_1 and Q_1Q_1	Q_2P_1 and P_1P_1	P_1P_1 and Q_1Q_1
Bimanual taught	.90	3.83	2.57	2.76	1.36	3.00	1.94
Bimanual untaught	1.66	1.91	2.14	1.88	.29	.00	.30
Bimanual total	2.35	5.29	2.27	1.73	.53	4.35	1.44
Unimanual taught	7.07	.24	1.11	1.38	2.22	1.55	.83
Unimanual untaught— equal opportunity	4.00	1.60	2.23	.49	1.35	.42	.61
Unimanual untaught— handicap offered	2.97	4.23	3.26	2.18	1.39	2.88	1.74
Unimanual total	4.61	1.62	.28	.60	.70	2.14	1.29
Hand preference total	1.11	1.07	3.11	2.90	.44	2.36	2.68

*These ratios may be viewed as minima, as the formula used to compute the *P.E. diff.* was $\sqrt{P.E._1^2 + P.E._2^2}$. Although the measures are correlated and hence the formula for the *P.E. diff.* of correlated variables should theoretically have been employed, it was questionable whether our distributions had the characteristics which would permit the use of the Pearson-Filon (5a) formulae for the correlation between correlation coefficients and hence the computation of the term $2r_1 P.E._1 P.E._2$.

TABLE 9

AVERAGE NUMBER FOR AN INDIVIDUAL AND SIGMA OF THE DISTRIBUTIONS OF THE NUMBER OF ITEMS IN WHICH SAME HAND WAS NOT USED IN THE TESTS COMPARED

Type of manipulation	Tests compared							
	Q ₁ P ₁ (201 cases)		Q ₂ P ₁ (50 cases)		P ₁ P ₁ (50 cases)		Q ₂ Q ₁ (50 cases)	
	Mean	Sigma of distribution	Mean	Sigma of distribution	Mean	Sigma of distribution	Mean	Sigma of distribution
Bimanual taught	1.29	1.26	1.16	1.02	.42	.60	.84	1.06
Bimanual untaught	1.51	1.32	1.56	1.18	.88	1.05	1.06	1.27
Bimanual total	2.80	1.95	2.72	1.91	1.30	1.20	1.90	1.96
Unimanual taught	1.15	1.28	1.12	1.13	.60	1.04	.56	1.04
Unimanual untaught— equal opportunity	2.92	2.18	2.32	2.22	1.96	1.92	1.82	1.85
Unimanual untaught— handicap offered	11.95	3.11	11.26	4.46	7.26	2.82	8.08	4.08
Unimanual total	16.02	5.27	14.70	6.09	9.82	5.06	10.46	4.81
Hand preference total	18.82	6.13	17.42	7.13	11.12	5.38	12.36	5.76

was altered in the second performance, the tasks designated "taught" being apparently somewhat more consistently performed than the "untaught." The reliability of the difference revealed by this latter comparison is statistically established. The unimanual activities showed perhaps a little less unreliability than the bimanual, except in the case of the position-handicap series. Here 14.8% of the time the hand chosen in the first performance test was not that elected to carry out the adjustment on the second. Hence, it is clear, we do have considerable variability in performance, in spite of the relatively consistent totals. As in the bimanual series, performance with respect to the "taught" items was less variable than that with respect to the "untaught."

Homogeneity and Predictive Value of the Tasks.

A procedure frequently designated as validation by internal consistency we have seen fit to employ in addition to the methods just described, because of the light it might throw on individual items. We do not feel, however, that the procedure should be viewed as one of validation, for a choice (provided it is correctly diagnosed) made in the case of single manipulations, whether or not it agrees with the trend shown in other items, is still a choice and might well be considered in estimating preference strength. Examination of individual items should be of value, then, primarily in determining the predictive value of the tasks.

The relationship of the performance on each manipulation to the score made on the basis of the various major groups of activities we first attempted to estimate by means of the biserial- r technique. Finding, however, that the corrections involved in this formula frequently resulted for our distributions in coefficients greater than unity, we have, on the advice of Dr. K. J. Holzinger, used the Pearson product-moment method. This has given us a series of uncorrected correlations which are probably somewhat too low and the probable errors of which we could not compute. In spite of these limitations, the correlations may doubtless be used safely for indicating trends and in making comparisons when the margins of difference are considerable.

Examination of the correlations (see Tables 11 and 12), all of which are based upon 200 cases, seems to justify the following generalizations and comment:

TABLE 10
RELATIVE FREQUENCY OF DISAGREEMENT BETWEEN HAND EMPLOYED IN VARIOUS QUESTIONNAIRE AND PERFORMANCE TESTS

Type of manipulation	Tests compared			
	Q3P ₁ (201 cases)	Q3P ₂ (50 cases)	P1P ₁ (50 cases)	Q2Q ₂ (50 cases)
	per cent	per cent	per cent	per cent
Bimanual taught	12.9	11.6	4.2	8.4
Bimanual untaught	15.1	15.6	8.8	10.6
Bimanual total	14.0	13.6	6.5	9.5
Unimanual taught	5.8	5.6	3.0	3.8
Unimanual untaught— equal opportunity	11.3	8.9	7.5	7.0
Unimanual untaught— handicap offered	24.4	23.0	14.9	16.5
Unimanual total	16.9	15.5	10.3	11.0
Hand preference total	16.4	15.1	9.6	10.7

TABLE 11
CORRELATIONS* BETWEEN PERFORMANCE IN THE INDIVIDUAL
MANIPULATIONS OF THE BIMANUAL SERIES AND SCORES
BASED ON VARIOUS GROUPS OF ACTIVITIES
PRODUCT-MOMENT METHOD

Manipulation number	Bimanual taught	Activity groups		Unimanual total	Hand preference total
		Bimanual untaught	Bimanual total		
Part I:					
Item 1	+.380	+.193	+.293	+.183	+.228
2	.617	.531	.607	.478	.504
3	.563	.249	.423	.328	.343
4	.590	.611	.613	.542	.563
5	.551	.260	.214	.218	.286
6	.441	.268	.361	.280	.299
7	.537	.480	.500	.560	.582
8	.435	.155	.204	.138	.144
9	.455	.275	.385	.215	.422
10	.596	.483	.590	.535	.563
Part II:					
Item 1	-.055	.341	.169	.011	.098
2	+.103	.470	.286	.127	.204
3	.174	.229	.236	.127	.159
4	.437	.560	.510	.498	.568
5	.374	.458	.463	.468	.467
6	.607	.540	.498	.547	.801
7	.667	.667	.745	.733	.746
8	.522	.597	.605	.585	.616
9	.124	.383	.278	.115	.127
10	.456	.661	.608	.524	.551

*Where sign is not given it is assumed to be positive.

TABLE 12
CORRELATIONS BETWEEN PERFORMANCE IN THE INDIVIDUAL
MANIPULATIONS OF THE UNIMANUAL SERIES AND SCORES
BASED ON VARIOUS GROUPS OF ACTIVITIES—
PRODUCT-MOMENT METHOD

Manipulation number	Activity groups					
	Unimannual taught	Unimannual untaught equal opportunity	Unimannual untaught handicap offered	Unimannual total	Bimannual total	Hand preference total
Part III:						
Item 1	+.597	+.537	+.461	+.590	+.439	+.554
2	.833	.721	.537	.705	.579	.695
3	.715	.745	.462	.704	.546	.690
4	.824	.747	.443	.695	.663	.670
5	.595	.466	.232	.431	.458	.419
6	.848	.790	.441	.728	.663	.742
7	.000	.000	.000	.000	.000	.000
8	.874	.740	.469	.711	.663	.726
9	.832	.799	.454	.741	.666	.746
10	.828	.724	.545	.707	.647	.726
11	.787	.740	.288	.670	.509	.686
12	.824	.750	.415	.700	.600	.714
13	.742	.716	.447	.668	.541	.669
14	.793	.707	.434	.670	.635	.686
15	.089	.185	.246	.219	-.016	.210
16	.794	.732	.424	.689	+.603	.696
17	.421	.305	.360	.459	.392	.454
18	.402	.418	.750	.524	.200	.490
19	.693	.714	.443	.654	.643	.830
20	.884	.851	.519	.797	.675	.801
Part IVA:						
Item 1	+.868	.738	.447	.685	.712	.699
2	.703	.873	.483	.796	.772	.808
3	.828	.786	.441	.667	.647	.661
4	.770	.817	.454	.730	.705	.722
5	.196	.407	.272	.327	.166	.315
6	.342	.475	.403	.462	.332	.437
7	.315	.366	.367	.434	.246	.407
8	-.079	.062	.006	-.002	-.031	-.026
9a	+.344	.423	.309	+.405	+.260	+.343
9b	.300	.437	.369	.378	.295	.415
10	.824	.810	.424	.705	.678	.689
11	+.818	+.826	+.422	+.759	+.725	+.758
12	.316	.427	.334	.423	.278	.432
13	.837	.769	.508	.704	.696	.725
14	.559	.737	.492	.617	.473	.610
15	-.068	.080	-.012	-.017	.164	-.075
16	+.175	.246	-.067	+.197	.214	+.217
17	.439	.554	+.466	.547	.397	.591
18	.511	.614	.442	.732	.538	.578
19	.654	.566	.140	.231	.170	.189
20	.865	.859	.523	.799	.720	.804
21	.748	.691	.404	.619	.605	.545
22	.329	.326	.203	.298	.203	.295
23	.362	.413	.351	.356	.342	.404
24	.453	.473	.214	.845	.458	.438
25	.846	.789	.497	.762	.749	.794

TABLE 12 (continued)

Manipulation number	Unimanual taught	Unimanual untaught-equal opportunity	Unimanual untaught-handicap offered	Unimanual total	Bimanual total	Hand preference total
Part IVB;						
Item 1a	.198	.237	.344	.300	.166	.293
1b	.166	.173	.401	.314	.112	.277
2a	.239	.280	.326	.306	.068	.289
3a	.316	.358	.349	.445	.241	.367
3b	.061	-.002	.205	.104	.027	.176
4a	.394	+.418	.356	.411	.341	.414
4b	.197	.220	.457	.375	.227	.324
5a	.336	.397	.293	.406	.244	.390
5b	.140	.187	.342	.285	.126	.288
6a	.093	-.037	.140	.128	.089	.110
6b	.143	+.151	.401	.299	.089	.266
7a	.154	.305	.358	.024	.124	.223
7b	.254	.260	.381	.323	.171	.402
8a	.182	.223	.360	.264	.166	.257
8b	.216	.327	.288	.363	.131	.310
9a	.471	.494	.384	.489	.411	.484
9b	.428	.390	.321	.428	.446	.442
10a	.078	.132	.277	.208	.081	.178
10b	.291	.350	.379	.400	.248	.407
11a	.275	.159	.159	.217	.127	.191
11b	.134	.182	.345	.268	.082	.234
12a	.392	.406	.329	.388	.323	.392
12b	.395	.439	.638	.508	.374	.456
13a	.337	.624	.429	.441	+.106	.626
13b	.500	.416	.193	.424	+.364	.494
14a	.170	.129	.392	.313	.246	.331
14b	.141	.144	.291	.207	.235	.204
14c	.136	.220	.429	.286	.172	.277
14d	.152	.167	.298	.201	+.059	.200
15a	.038	.110	.209	.167	+.001	.117
15b	.121	.178	.296	.240	.269	.251
16a	.259	.263	.257	.307	.143	.306
16b	.261	.308	.499	.416	.234	.397
17a	-.036	-.041	.006	-.012	-.031	-.019
17b	+.111	+.106	.316	+.197	+.061	+.206
18a	.104	.122	.225	.191	-.160	.159
18b	.130	.093	.232	.140	+.073	.144
19a	.368	.336	.230	.351	.335	.347
19b	.239	.269	.400	.168	.175	.320
20a	.497	.509	.448	.599	.419	.517
20b	.603	.624	.524	.653	.592	.672
21a	.117	.109	.350	.251	.007	.239
22a	-.157	-.087	.148	-.021	-.190	.038
22b	+.173	+.190	.285	+.253	+.221	.237
23a	.315	.345	.577	.498	.313	.487
24a	-.326	-.334	-.224	-.347	-.101	-.319
24b	-.295	-.319	-.156	-.297	-.289	-.293
25a	+.780	+.740	+.495	+.785	+.618	+.734
25b	.670	.646	.445	.689	.545	.615

1. Practically all of the correlations are positive, though many are low and few are higher than .80. The range in size of the coefficients, then, is great, and one may conclude with assurance that the items vary considerably in predictive value.

2. The performance upon most of the specific items tends to be more closely related to scores on the activity groups in which these items occur than to scores based on other activity groups; but these differences in degree of relationship, while usually consistent, are, in the main, not great.

3. The bimanual tasks correlate to a lower degree with scores for the various series of manipulations than do the unimanual tasks, with the exception of the handicap series.

4. The correlations for the unimanual-handicap series are generally lower than for the other series.

5. In the handicap series, performance, when the object to be manipulated is placed nearer the right hand than the left, shows no uniformly closer relation to preference trends in the groups of activities than when the reverse is true as far as placement is concerned.

6. Some of the behavior patterns used by other authors as representative of certain types of manual activities show little relationship to performance in our samples of these types. For instance, the position of the hand on the broom handle (Part II, Item 1) seems to have little diagnostic value. In fact, of the 10 items in our series, it has the lowest correlation with the section score. We would also call attention to the results from the introspections of a small group of our S's.

Since 29 out of 48 S's, as they observed themselves, believed that the hand farthest from the base of the broom did most of the work, neither hand position, i.e., low or high on the handle, could be accepted arbitrarily as an expression of domination. Ojemann (12) and Cuff (4) also found this index, which Downey (5) first discusses, to be questionable.

Of course, it should be stressed that, although Downey used behavior during sweeping activities in her threefold classification scheme, she seemed to realize the difficulty we have noted, for she created in one of her three classes a number of sub-types. We merely would make the point that, while the manual choice in sweeping is interesting and significant, we should not select it as the adjustment from which we should attempt to predict behavior in other bimanual tasks in which the effects of tutoring are believed to be a minimum.

In regard to the diagnostic value of another item—thumb uppermost when hands are clasped (Part II, Item 9)—our results seem to suggest that less faith is warranted than Downey gives. While it is true that the data in Table 13 (in the construction of which techniques for evaluating items were employed similar to those followed by Downey) are not entirely out of line with her assertions, the table does reveal the *relative* unsatisfactoriness of the thumb-out criterion and shows the limitations of such statements as the following one of Adler's: "One simple but not entirely conclusive method for finding out whether a child is congenitally left-handed is to ask the child to cross his

TABLE 13
IN THE TWO GROUPS WHO REACTED USUALLY WITH THE RIGHT HAND AND USUALLY WITH THE
LEFT IN TWENTY SELECTED MANIPULATIONS, THE NUMBER AND PERCENTAGE IN THE
CASE OF EACH INDIVIDUAL MANIPULATION OF THOSE WHO EMPLOYED THE
RIGHT HAND AND WHO EMPLOYED THE LEFT

Manipulation number	Right-handed group		Left-handed group		Total group		Right-handed group		Left-handed group		Total group	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Part I:												
Item 1	122	64	5	10	127	74	65.6	34.4	33.3	66.7	63.2	36.8
2	178	8	6	9	184	17	95.7	4.3	40.0	60.0	91.5	8.5
3	140	46	3	12	145	58	75.2	24.8	20.0	80.0	71.1	28.9
4	185	1	7	8	192	9	99.5	0.5	46.7	53.3	95.5	4.5
5	123	63	2	13	125	76	66.1	33.9	13.3	86.7	62.1	37.9
6	164	22	8	7	172	29	88.2	11.8	53.3	46.7	83.5	14.5
7	185	1	7	8	192	9	99.5	0.5	46.7	53.3	95.5	4.5
8	165	21	9	6	174	27	88.7	11.3	60.0	40.0	86.5	13.5
9	175	11	7	8	182	19	94.1	5.9	46.7	53.3	90.5	9.5
10	174	12	3	12	177	24	93.5	6.5	20.0	80.0	88.5	11.5
Part II:												
Item 1	106	80	6	9	112	89	57.0	43.0	40.0	60.0	55.7	44.3
2	124	62	5	10	129	72	66.7	33.3	33.3	66.7	64.1	35.9
3	135	51	6	9	141	60	72.6	27.4	40.0	60.0	70.1	29.9
4	174	12	5	10	179	22	93.5	6.5	33.3	66.7	89.0	11.0
5	139	47	4	11	143	58	74.8	25.2	26.7	73.3	71.1	28.9
6	186	0	7	8	193	8	100.0	0.0	46.7	53.3	96.2	3.8
7	185	1	2	13	187	14	99.5	0.5	13.3	86.7	93.0	7.0
8	168	18	3	12	171	30	90.3	9.7	20.0	80.0	85.1	14.9
9	106	80	5	10	111	90	57.0	43.0	33.3	66.7	55.2	44.8
10	169	17	1	14	170	31	90.8	9.2	6.7	93.3	84.1	15.9
Part III:												
Item 1	167	19	4	11	171	30	89.6	10.4	26.7	73.3	85.1	14.9
2	185	1	7	8	192	9	99.5	0.5	46.7	53.3	95.5	4.5
3	183	3	4	11	187	14	98.4	1.6	26.7	73.3	93.0	7.0
4	186	0	2	13	188	13	100.0	0.0	15.3	86.7	93.5	6.5

TABLE 13 (continued)

Manipulation number	Right-handed group		Left-handed group		Total group		Right-handed group		Left-handed group		Total group	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
5	170	16	5	12	173	28	91.4	8.6	20.0	80.0	86.1	13.9
6	186	0	5	12	189	12	100.0	0.0	20.0	80.0	94.0	6.0
7	186	0	15	0	201	0	100.0	0.0	100.0	0.0	100.0	0.0
8	186	0	4	11	190	11	100.0	0.0	26.7	73.3	94.6	5.4
9	185	1	2	13	187	14	99.5	0.5	13.3	86.7	91.0	9.0
10	181	5	2	13	183	15	97.3	2.7	13.3	86.7	91.0	9.0
11	185	1	5	10	190	11	99.5	0.5	33.3	66.7	94.6	5.4
12	185	1	5	12	188	13	99.5	0.5	20.0	80.0	93.6	6.4
13	185	1	6	9	191	10	99.5	0.5	40.0	60.0	95.0	5.0
14	186	0	4	11	190	11	100.0	0.0	26.7	73.3	94.6	5.4
15	180	6	14	1	194	7	96.8	3.2	93.3	6.7	96.5	3.5
16	185	1	4	11	189	12	99.5	0.5	26.7	73.3	94.0	6.0
17	121	1	3	12	124	15	65.1	34.9	23.0	80.0	61.5	38.5
18	185	2	12	3	197	4	99.5	0.5	80.0	20.0	98.0	2.0
19	184	2	5	10	189	12	98.9	1.1	33.3	66.7	94.0	6.0
20	184	2	1	14	185	16	98.9	1.1	6.7	93.3	92.0	8.0
Part IV.A:												
Item 1	186	0	2	15	188	13	99.5	0.5	13.3	86.7	93.5	6.5
	185	1	0	15	186	16	98.9	1.1	0.0	100.0	92.0	8.0
2	183	3	1	14	184	17	98.4	1.6	6.7	93.3	91.5	8.5
3	185	1	1	14	186	15	98.9	1.1	6.7	93.3	92.5	7.5
4	185	1	1	14	186	15	98.9	1.1	6.7	93.3	92.5	7.5
5	180	36	2	7	188	23	98.7	1.3	51.3	48.7	75.6	24.4
6	181	25	6	6	187	34	98.5	1.5	40.0	60.0	81.1	18.9
7	188	22	7	8	193	35	98.0	2.0	46.7	53.3	82.1	17.9
8	11	175	2	15	183	17	99.5	0.5	13.3	86.7	93.5	6.5
9	180	4	9	6	190	14	96.5	3.5	6.7	93.3	94.0	6.0
10	93	93	1	15	93	17	98.9	1.1	0.0	100.0	92.0	8.0
11	185	1	4	11	189	12	99.5	0.5	26.7	73.3	94.0	6.0
12	182	4	1	14	183	15	97.8	2.2	6.7	93.3	91.0	9.0
13	185	21	2	6	184	27	98.7	1.3	62.0	38.0	86.6	13.4
14	185	1	2	15	187	14	99.5	0.5	13.3	86.7	93.5	6.5
15	185	1	2	15	187	14	99.5	0.5	13.3	86.7	93.5	6.5
16	183	3	5	7	191	14	98.4	1.6	51.3	48.7	95.0	5.0

TABLE 13 (continued)

Manipulation number	Right-handed group		Left-handed group		Total group		Right-handed group		Left-handed group		Total group	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
15	70	116	8	7	78	125	37.6	62.4	53.3	46.7	59.7	61.3
16	165	25	8	7	171	50	87.6	12.4	51.3	46.7	55.1	14.9
17	169	17	7	7	176	25	90.8	9.2	46.7	53.3	87.6	12.4
18	175	15	4	11	177	24	93.0	7.0	26.7	73.3	83.0	12.0
19	185	1	7	8	192	9	99.5	0.5	46.7	53.3	98.0	4.0
20	186	0	1	14	187	14	100.0	0.0	6.7	93.3	93.0	7.0
21	177	9	3	12	180	21	93.1	4.9	20.0	80.0	89.5	10.5
22	186	0	12	5	198	3	100.0	0.0	80.0	20.0	98.5	1.5
23	165	21	8	7	173	28	88.7	11.3	53.3	46.7	86.1	13.9
24	186	0	11	4	197	4	100.0	0.0	73.3	26.7	98.0	2.0
25	184	2	1	14	185	16	98.9	1.1	6.7	93.3	92.0	8.0
Part IVB:												
Item 1a	97	89	3	12	100	101	52.1	47.9	20.0	80.0	49.7	50.3
1b	64	122	2	13	65	155	34.3	65.7	13.3	86.7	32.8	67.2
2	170	16	10	5	180	21	91.4	8.6	33.3	66.7	89.5	10.5
3a	175	11	9	6	184	17	94.1	5.9	60.0	40.0	91.5	8.5
3b	168	18	12	3	180	21	90.5	9.7	80.0	20.0	89.5	10.5
4a	170	16	8	7	178	23	91.4	8.6	53.3	46.7	88.6	11.4
4b	102	84	3	12	105	96	55.0	45.0	20.0	80.0	52.2	47.8
5a	184	2	12	3	196	5	98.9	1.1	80.0	20.0	97.5	2.5
5b	30	156	0	15	30	171	35.2	64.8	0.0	100.0	14.9	85.1
6a	181	5	14	1	195	6	97.3	2.7	93.3	6.7	97.1	2.9
6b	29	157	0	15	27	172	34.8	65.2	0.0	100.0	14.5	85.5
7a	173	13	11	4	184	17	93.0	7.0	73.3	26.7	91.5	8.5
7b	117	69	2	13	119	82	63.0	37.0	13.3	86.7	59.2	40.8
8a	135	51	7	8	142	59	72.6	27.4	46.7	53.3	70.6	29.4
8b	174	12	11	4	185	16	93.5	6.5	73.3	26.7	92.0	8.0
9a	160	26	2	13	162	39	86.0	14.0	13.3	86.7	80.6	19.4
9b	151	35	2	13	153	48	81.2	18.8	13.3	86.7	76.1	23.9
10a	153	38	10	5	158	43	79.6	20.4	66.7	33.3	78.6	21.4
10b	96	90	1	14	97	104	51.6	48.4	6.7	93.3	48.1	51.9
11a	168	18	10	5	178	23	90.3	9.7	66.7	33.3	88.6	11.4

TABLE 13 (continued)

Manipulation number	Right-handed group		Left-handed group		Total group		Right-handed group		Left-handed group		Total group	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
11b	120	66	5	10	125	76	64.5	35.5	53.5	66.7	62.1	37.9
12a	170	16	6	9	176	25	91.5	8.7	40.0	60.0	87.6	12.4
12b	144	42	2	13	146	55	72.4	22.6	15.3	86.7	72.6	27.4
13a	120	66	2	13	122	79	64.5	35.5	13.3	86.7	60.7	39.3
13b	182	4	8	7	190	11	97.8	2.2	55.5	46.7	94.6	5.4
14a	156	30	9	6	165	36	83.9	16.1	60.0	40.0	82.1	17.9
14b	90	96	5	10	95	106	48.2	51.8	33.3	66.7	48.2	51.8
14c	130	56	5	10	135	66	69.9	30.1	33.3	66.7	67.1	32.9
14d	120	66	9	6	129	72	64.5	35.5	60.0	40.0	64.1	35.9
15a	30	156	3	12	33	168	35.5	64.7	20.0	80.0	16.5	83.5
15b	174	12	12	3	186	15	93.5	6.5	80.0	20.0	92.5	7.5
16a	169	17	10	5	179	22	90.8	9.2	66.7	33.3	89.0	11.0
16b	83	103	1	14	84	117	44.5	55.5	6.7	93.3	41.7	58.3
17a	182	4	15	0	197	4	97.8	2.2	100.0	0.0	98.6	2.0
17b	24	162	0	15	24	177	12.7	87.3	0.0	100.0	12.0	88.0
18a	57	129	2	13	59	142	30.5	69.5	13.3	86.7	29.4	70.6
18b	153	33	11	7	164	57	82.3	17.7	73.3	26.7	81.5	18.5
19a	176	10	8	7	184	17	94.6	5.4	53.5	46.7	91.5	8.5
19b	172	14	0	15	172	129	93.6	6.4	0.0	100.0	93.9	6.1
20a	172	14	6	9	178	23	92.5	7.5	40.0	60.0	88.0	12.0
21a	71	115	2	13	73	27	92.5	7.5	13.3	86.7	86.0	14.0
21b	27	159	0	15	27	174	38.0	62.0	26.7	73.3	32.6	67.4
22	158	28	4	11	162	39	14.4	85.6	0.0	100.0	13.4	86.6
23a	153	33	9	6	162	39	83.3	16.7	26.7	73.3	57.9	42.1
23b	139	60	2	13	153	73	57.9	12.1	13.3	86.7	93.9	6.1
24a	19	157	9	6	38	163	34.8	62.2	60.0	40.0	18.9	81.1
24b	29	166	7	5	37	174	10.5	89.5	46.7	53.3	13.4	86.6
25a	185	1	5	10	193	11	99.5	0.5	33.3	66.7	94.6	5.4
25b	179	7	3	12	182	19	96.2	3.8	20.0	80.0	90.5	9.5

hands. Left-handed children usually cross their hands so that the left thumb lies over the right. It is astounding how many people have been born left-handed and have never known it" (1, p. 46).

It should be added that Adler mentions no other test of hand preference in his discussion, and certainly the one to which he alludes seems only very slightly related to other manual choice behaviors. He offers, moreover, no evidence for his faith in the hand-clasping test as diagnostic of native handedness, whatever that is.

The hand most active when a needle is being threaded (Part III, Item 5) is still another one of the frequently quoted indices of hand preference over the relative predictive value of which our findings throw some doubt.

7. Of the tasks labelled "unimanual taught," those which show the very highest correlation with group scores seem to be not those concerning which mere personal instruction and verbal direction has been received but those in which there has been inherent in the everyday situation factors favoring the choice of the right hand. Stamps, for instance (Part III, Item 20), custom dictates, must be placed in the upper right-hand corner of the envelope.

8. Activities which may be described as primarily holding and carrying, i.e., holding a mirror (Part IVA, Item 5), carrying a book (Part IVA, Item 15), carrying a pail (Part IVB, Items 24*a* and 24*b*), tend to be among those with low coefficients. It is probable here that, though both hands are free, the habits are

still exerting themselves which were built up in those frequently occurring situations in which both hands are occupied, and holding or carrying is the least skillful of the manipulations demanded. About three-fifths of our S's, for instance, carried books with their left hands. This is increased to only about five-sixths when the S is asked to carry an umbrella in addition to books.

9. Differences in racial tradition among our S's has, presumably, had something to do with the moderate size of the coefficients we obtained in the case of such items as Part III, Item 1. English and American custom concerning the hand to be used when food is conveyed to the mouth with a fork seem to be at variance.

10. Among the tasks having relatively low coefficients of correlation with the section scores, though practically all are still positive, are the following: guiding the metal arm of a brace, swinging a golf club (hand lowest on the handle), clasping hands (thumb uppermost), wearing a watch (hand upon which worn), carrying books, turning a doorknob at one's left, opening a drawer at one's right, whisking a thread from one's right shoulder, removing the right or left shoe, erasing a blackboard, and carrying a bucket when ascending or descending a ladder.

11. Relatively high correlations were obtained for the following manipulations: washing dishes (hand on the rag), guiding a bodkin, beating eggs, holding a soup spoon, turning a faucet, stamping an envelope, wielding a tennis racket, throwing a ball, spinning a

top, combing one's hair, brushing clothes, striking a match on the sole of one's shoe, placing pegs in a peg-board, brushing up trash (hand on the brush), and throwing a rope for jumping rope.

Extreme-Group Method of Evaluating Individual Items. As a further means of investigating the individual items, we noted how well they differentiated between two groups, one of which was strongly left-handed and the other right-handed. We selected 20 items (proportionately from the various sections) which correlated highest with the score of the section in which they fell and with the total hand-preference score and rated each S's performance on the basis of these. We thus obtained two groups, one of which seemed strongly biased in favor of the left and the other somewhat more in favor of the right. (A complete discussion of this will be given in a subsequent section.) We then noted the percentage of each of these two groups who reacted with the right hand to each of the tasks and the percentage who reacted with the left. (See Table 13.) This method of estimating the predictive value of an item is often called the method of extreme groups.

Since it is probable that an individual's total score obtained as we have described is strongly influenced by relative skill and perhaps even by native influences, the tasks performance in which is most disparate in the so-called right- and left-handed groups we might suspect to be those weighted heavily by the aforesaid factors.

Again it is apparent that the various tasks call forth with greatly varying frequency a right-handed per-

formance. Among the items in which 85% of the left-handed group performed left, whereas at least 50% less of the right-handed group performed left are: Part I, Item 4; Part II, Items 6, 7, and 10; Part III, Items 4, 9, 10, and 20; Part IVA, Items 1, 2, 3, 4, 11, 13, 20, and 25; and Part IVB, Items 9a, 9b, and 20b.

These results, then, and those of Tables 11 and 12 showing the correlations of each item with the total section scores, suggest that many factors influence preference or manual choice. Even the concept of relative skill probably must be viewed in part as relative to the situations. The greater internal consistency among the unimanual than the bimanual series, among the taught than the untaught, etc., intimates that there are large classes of influences operating to determine strength of preference— influences such as teaching, convenience, and example— as well as many which may be trivial in nature. The striking fact of consistency argues also for a strong constant biasing force or forces. Of the probable nature of these more will be said in a later section.

B. THE QUESTIONNAIRE

Reliability of the Questionnaire. The correlations obtained between the scores on the two questionnaires are not essentially at variance with those obtained on the performance test. (See Tables 7 and 8.) The coefficients of reliability in the case of the questionnaire, furthermore, are, on the whole, not grossly different for the various groups of activities; but, as was noted in the performance test, the "taught" items seem to exhibit

slightly more consistency than the "untaught," and the unimanual, with the exception of the handicap series, than the bimanual.

A study of extent of agreement with respect to the responses to individual items in the two questionnaires supports in most respects the correlation findings. (See Table 9.)

Validity of the Questionnaire. It is conceivable that, while an individual may report consistently with respect to his probable manual behavior, his opinions may be incorrect. Hence, it was thought desirable to correlate the scores on the questionnaire with those on the performance test. The results in Tables 7, 8, 9, 10, and 4 reveal that one's statement with respect to his bimanual activities and such items as are included in the section designated "Unimanual Untaught—Handicap Offered" are not to be entirely trusted. About 14% of the time in the former and 24% in the latter our S's "were in error." The manipulations in the unimanual taught series, with the exception of those in which the position handicap was imposed, were generally more accurately specified than those in the bimanual taught series; and the same sort of relationship was observed for the taught and untaught. The S's, it seems reasonable to infer, found it difficult to estimate what adjustments they would make to handicaps in positions as vaguely described as those in the questionnaire. The other possible interpretations are, of course: (1) that, where there was disagreement, the questionnaire account was correct and the non-preferred hand in certain items chanced to be used; (2) there is no

preferred hand for certain of the tasks; or (3) the S's were unaware of the pattern of their habits. The second explanation is not very convincing as far as most items are concerned, in the light of the consistency shown between the two preference tests; but it may be an explanation of a few of the cases. We should also be inclined to place a little faith in argument (1) with relation to one or two manipulations. Since, however, questionnaire and performance tests agree well, though slightly less than the two performance tests, or the two questionnaires, ignorance of one's habits, it does seem, is the most probable explanation of many of the divergences between actual preference behavior and written report thereon. Taking the series of tasks as a whole, however, we may safely say that the questionnaire is a *fairly* valid measure of *degree* of hand preference, if the performance test is a valid measure, but the extent to which an S's report regarding his habit with respect to a particular manipulation is to be depended upon varies with the type of task.

Effect of Repetition upon the Reliability Coefficients. That accuracy of report increases with repetition, or performance is stabilized, or both, is indicated by the fact that the correlations between the results of the second questionnaire and performance tests are generally a little higher than those for the first questionnaire and first performance test. (See Table 7.)

Report and Strength of Preference. A study of the group averages given in Table 5 and the quotients in Table 14 indicates that the S's tend, on the average, in the bimanual series to report themselves more strongly right-handed than actual manipulations reveal

TABLE 14
RATIOS OF THE DIFFERENCE BETWEEN THE MEAN SCORES MADE
BY THE TOTAL STUDENT GROUP ON THE FIRST PERFORMANCE
TEST AND FIRST QUESTIONNAIRE AND THE PROBABLE
ERROR OF THESE DIFFERENCES

Types of manipulation	Diff.	P.E. _{diff.}	Diff. P.E. _{diff.}
Bimanual taught	-1.00	.560	-7.14
Bimanual untaught	-2.59	.688	-3.76
Bimanual total	-1.13	.506	-8.16
Unimanual taught	+1.20	.291	+4.10
Unimanual untaught—equal opportunity	+1.15	.420	+2.74
Unimanual untaught—handicap offered	-1.40	.567	-2.47
Unimanual total	-0.50	.343	-1.46
Hand preference total	-0.65	.397	-1.64

them to be, whereas in two of the unimanual series the reverse obtains. Most of the ratios in Table 14 have considerable size.

Summary Regarding the Questionnaire. Since the questionnaire and performance tests correlate to a slightly less degree than do the two performance tests, the validity of the questionnaire seems established as a measure of *degree* of hand preference, if the performance tests are valid. The questionnaire, it appears, could be used in general diagnosis as a substitute for the latter. As far as our groups of activities are concerned, of course, one might expect the report to be incorrect anywhere from about 6 to 24% of the time, depending on the nature of the group.

With the probable values and limitations of our measuring instruments in mind, we may now proceed to a consideration of some of the more fundamental problems of determination.

III

DISTRIBUTION OF DEGREES OF HAND PREFERENCE

Theoretical Considerations. The problem of the nature and determinants of hand preference is one fraught with many of the same difficulties that have obscured the way in the analyses of other phases of the question of mental organization. Here we frequently find ourselves seeking the solution of questions the very assumptions underlying which may be unfruitful and obstructive to progress, or we lose or vary unwittingly our objective as we slip from one tacit assumption to another. To illustrate our contention, let us list some of the basic problems that confront us as we study. Is what we term an "influence" a construct mediated by a comparison and definable only in terms of that comparison? If so, it is highly important to describe fully the comparison. Is hand preference to be conceived as descriptive of objective behavior, to be measured, accordingly, by summing the choices manifested in a multitude of tasks, and explained in terms of such variables as vary with it? Or is it to be dealt with as an explanation, a unit factor, perhaps.

With presumably little more than casual observation to guide them, many workers have seemingly conceived of hand preference as the expression of an entity of some sort, which can be revealed as well by one task as by another, for they have used one or a very limited number of examples of behavior as representative of

an individual's activities. Some investigators have even alleged the problem of differences in handedness to be solved, offering such solutions, for example, as: (1) eye preference (which is in turn sometimes looked upon as an entity or expression of a single genetic conformation), (2) a dominant hemisphere, (3) the relative length of the humeruses of the two arms, or (4) the relative substantialness of the two legs, or the two sides of the body, etc. The possible fruitfulness of the hypothesis that manual choice behavior may be a product of a multiplicity of genetic influences, including more than workers have had the ingenuity to suggest, seems to have received none too much consideration. Although admitting the difficulty of dividing genetic influences, we do not feel the evidence at present justifies us in assuming hand preference to be solely an expression of metabolic balance in the germ-cell or some other single basic condition any more than it does in assuming preference to be the integrated effect of the influences of eye preference, jaw preference, ear preference, touch preference, or their conditioners, etc., each of which may be relatively independent of the others in the same sense that eye color, while a product of many genes, may be in certain species, as compared with others, *relatively* independent of height. Certainly, to proceed without exploring both types of hypotheses puts us in the position of accepting as given what needs to be demonstrated.

Environmental and tuitional influences, too, have in occasional investigations on hand preference been treated as identical, as well as unitary, mechanisms.

It has only too frequently been argued, for example, that because certain tuitional influences have appeared as improbable contributors in a certain comparison, environmental factors have been ruled out. Yet we have evidence that the direction of growth in a cell can be conditioned in part by electrical influences supplied artificially and that x-raying modifies fundamental characters of species. While neither of these, surely, could be described as tuitional, they are environmental, and it is conceivable that they might be rather directly related to manual choice behavior.

To repeat, we maintain that it is a short-sighted policy which could cause us to fail to investigate a multiplicity of relations. Although hand preference, undoubtedly, is an abstraction in a degree, our conception of it should be built upon extensive observation of behavior. In the case of curves expressive of the distribution of hand-preference scores, we should be interested in the fact of dispersion as well as in the characteristics of skewness or the number of modes. Should we find a wide dispersion, this would suggest that a multitude of factors determines our manual choices. Should the curves be unimodal, hand preference would appear to be a trait like honesty perhaps, continuous but with the extremes conversely labelled. If, on the other hand, as has been alleged, the right-handed and left-handed differ primarily, but not necessarily wholly, because of their basic biological organization, i.e., are two distinct biological types, then we would expect our frequency distributions to be bimodal. We admit, however, that a tendency to a second mode could

be obliterated by strong cultural influences working counter to the biological. We also think it possible that bimodality may be created by selecting activities for consideration in which the performance of the right and left hand differ most markedly, since we do not know the factors which mediate this inequality.

Frequency Distributions. Our distribution curves for scores based upon all of the various groups of activities show a continuity in degree of bias for the right hand, ranging from the almost invariable choice of the right hand in the case of certain individuals to the almost invariable choice of the left on the part of others. (See Figures 1-3.) They are decidedly skewed to the right; but a second mode, or third mode, as the common tripartite division would suggest, is not entirely convincingly present. This is not in accord with Ojemann's findings, though in some of our distributions, we admit, there is a *suggestion of bimodality*.

With a distribution based upon 200 cases, it is true, one cannot dogmatize in regard to curve form; nor would he be justified in attempting such elaborate methods of curve fitting as Pearson has devised. Hence, our method of estimating the probable significance of

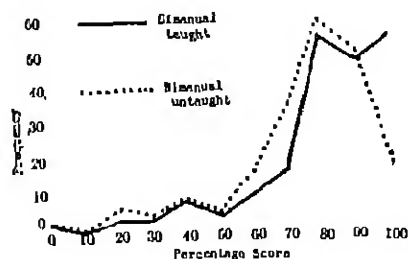


FIGURE 1

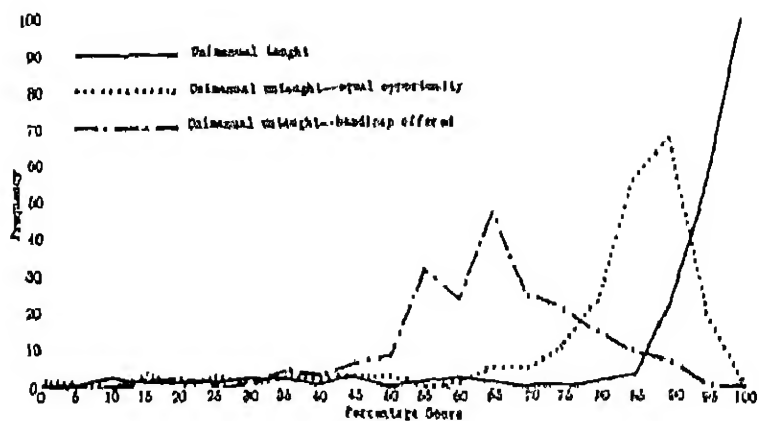


FIGURE 2

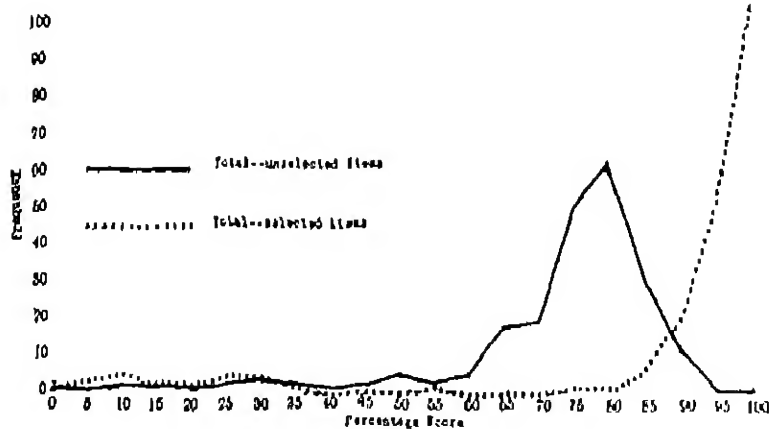


FIGURE 3

TABLE 15
FREQUENCY DISTRIBUTIONS FOR THE SCORES BASED ON VARIOUS GROUPS OF ACTIVITIES

Inter-vals	Total hand preference	Bimanual taught	Bimanual untaught	Uni-manual taught	Unimanual untaught—equal-opportunity	Uni-manual untaught—handicap offered	Twenty selected items (female)	Twenty selected items (male)	Twenty selected items (male and female)
100	0	55	18	98	0	0	81	24	105
95-99	0			54	20	0	37	16	55
90-94	11	48	51	23	67	6	15	7	20
85-89	31			3	55	9	3	3	6
80-84	62	55	59	1	25	14	1		1
75-79	49			0	10	21		1	1
70-74	19	17	36	0	5	24			
65-69	17			1	5	47			
60-64	4	10	16	2	1	24			1
55-59	2			1	0	31	1		
50-54	4	3	4	0	2	9			
45-49	2			2	2	6			
40-44	1	8	8	1	2	3			
35-39	2			2	2	4	1		1
30-34	3	2	3	2	1	1	3	3	3
25-29	2			1	2	0	3		3
20-24	0	2	5	1	0	1			
15-19	1			1	3	1	1		1
10-14	1	0	0	2	0	0	2	2	4
5-9	0			0	0	0	2		2
0-4	0	1	1	0	1	0			

TABLE 16
PROBABLE ERRORS OF CERTAIN FREQUENCIES IN THE
DISTRIBUTIONS

Frequency	Probable error of frequency	Difference between critical intervals
1	.67	1 or 2
2	.95	2
3	1.16	5
4	1.34	4
8	1.87	4
24	3.11	7
31	3.45	7

those curve characteristics which we suspected might be modes was to compare simply the probable error of the frequencies for critical intervals—intervals showing the reduction in number of cases which would be suggestive of a minimum—and the frequency difference between the critical interval and the subsequent one. The probable errors of the frequencies we examined are given in Table 16. They are based on the formula $P.E._f = .6745 f \left(1 - \frac{f}{n}\right)$. The frequency distributions for various groups of activities are presented in Table 15 and Figures 1-3.

In two cases (see distributions for the bimanual activities) criteria suggestive of a highly probable interval-frequency difference are present. In the other distributions, moreover, the ratios examined were usually over 2.00. It is also noteworthy that, in spite of the difference in skewness exhibited by the distributions, the tails (indicating extreme preference for the left hand) cover about the same range of scale, i.e., are practically never curtailed, and that three of the

five curves show their first depression at the same relative point on the scale. The locus of the first depression in one of the two curves, it is well to add, does not deviate more than one interval from that shown in the other three; and the percentage of individuals below the first minimum is approximately the same. These facts, then, taken in mass, might make one rather suspicious of the presence of two types of individuals, although we have little to guide us in estimating the influence of the selection of tasks upon the form of the distribution curve.

To illustrate this effect of the tests used, we may compare the distributions of scores based upon all of the items in the various sections with that for the scores based upon 20 selected items. The 20 items correlating highest with the particular sections in which they were found and with the total hand-preference scores were chosen from the various sections in the following proportions: Bimanual Taught, 2 (Items 4 and 7); Bimanual Untaught, 2 (Items 6 and 7); Unimanual Taught, 5 (Items 2, 6, 8, 9, and 20); Unimanual Untaught—Equal Opportunity, 5 (Items 1, 2, 13, 20, and 25); and Unimanual Untaught—Handicap Offered, 6 (Items 9a, 9b, 13b, 20b, 25a, and 25b). As is apparent, these 20 items were apportioned between the various sections approximately as the ratio of the number of tasks in the latter to the whole series of 105 manipulations.

The distribution curve for the scores based upon the specially selected series of tasks shows a clear-cut bimodality. Only one person fell within the score range

between 75 and 35. The 14 individuals who scored below 35 represent a proportion ($.0606 \pm .016$) of the total group which is not far from the one Ojemann (11) offers as the incidence of left-handedness in the population. While Jones (9), who also notes bimodality in his dextrality ratios, presents no exact figures, his graph indicates that about 10% of his subjects, who were preschool children, fell in the left mode.

Interpretation of Frequency Distributions. The meaning of this difference in the distributions of scores based upon selected and unselected items is not unambiguous; but it seems likely that the latter series has called into play a greater variety of factors than the former. It is even probable that we were wrong at times in the latter series in our diagnosis of a right-handed performance, when that is defined in terms of relative difficulty. This hypothesis seems plausible in the case of some of the bimanual activities, as we have already indicated; but the argument is not cogent in the case of the first section of the unimanual tasks. It is also possible that in manipulations requiring little skill the hands are used more nearly indiscriminately. Inconspicuous phases of body mechanics and situational convenience may weigh more heavily as the determinants. The 20 items, in keeping with this hypothesis, seem, on the whole, to be ones demanding relatively more delicate manipulations than many in the unselected series. It is probable, too, that choice habits may have influenced certain of the unselected items to a marked degree. The habit of carrying with the left hand may have persisted in those situations in which the right is not occupied.

Ojemann's (11) findings also support our theory of multi-causality. He noted, for example, that no one task could be relied upon to yield an accurate picture of differences in manual skill, even when the operations required rather delicate adjustments and differences in skill were carefully measured.

To summarize, let it be said that scores based upon certain selections of tasks show clearly bimodal distributions, a fact suggestive of some general biasing influence or influences and seemingly more readily interpretable in terms of some fundamental organismal quality rather than experiential. It is not necessary, however, to assume a genetic factor or factors to account for the phenomenon. (2) The method of measuring hand preference does apparently influence the results obtained. Scores expressive of a trend among a large number of common and varied tasks do not show an unmistakable bimodal distribution. (3) Since even in the bimodal distributions there is some dispersion in the measures, it is probable that many influences affect manual choice.

IV

FAMILY RESEMBLANCE

Correlation between Sibs' Scores. Because of the bimodality in certain distributions—a condition suggestive of types—it has seemed well to question whether these are genetically determined or an expression of influences operating very early in the organism's development but little related to the fundamental organization of the germ-cell. Although we admit that we cannot settle the issue, we have attempted to get such light as a study of various forms of family resemblance can shed. Family resemblance alone is, of course, of little significance; but this, coupled with the evidence from bimodality even though this combination of evidence is not entirely conclusive, would make plausible the hypothesis of hereditary determinants of individual differences. The reader should recall that Gesell (6, p. 80) is not convinced of any real hand preference in infants much before the second half-year of life. This means that the genetic approach to the problem has not succeeded in eliminating the possibility of even cultural determinants, much less prenatal biological ones.

We investigated first the correlations between the hand-preference scores of 43 pairs of sibs.² Thirteen of the sib pairs were of opposite sex; 30, of the same.

²Amanda Herring and Ruth Reed worked on this phase of the study.

TABLE 17
DOUBLE-ENTRY CORRELATIONS BETWEEN THE HAND-PREFERENCE
SCORES OF SIBS

Type of manipulation	Like-sex sibs (30 pairs)	Unlike-sex sibs (13 pairs)
Bimanual taught	— .113 ± .090	— .023 ± .123
Bimanual untaught	+ .196 ± .087	— .118 ± .121
Bimanual total	+ .017 ± .090	— .248 ± .115
Unimanual taught	— .111 ± .090	+ .058 ± .122
Unimanual untaught—equal opportunity	+ .060 ± .090	+ .023 ± .123
Unimanual untaught—handicap offered	+ .501 ± .068	+ .205 ± .118
Unimanual total	+ .225 ± .086	+ .159 ± .120
Hand preference total	+ .185 ± .088	+ .091 ± .122
Twenty selected items	— .060 ± .090	— .001 ± .135

The correlations were obtained by the double-entry method.

With the exception of that for sibs for the same sex in Part IVB, correlations are all insignificant. Some of the coefficients are negative. (See Table 17.)

The failure of sibs' scores to correlate—a correlation might be expected even on the basis of experience common to the family—may mean that the factors making for general dispersion in the distributions are more or less incidental environmental ones. One might also argue that a tendency among sibs toward the same biological type, since the left type is rare, would probably not be revealed among as few S's as we had.

Coefficients of Correlation between Hand-Preference Scores and the Possession of Left-handed Relatives. As an attack on the point just stated and as a means of increasing cases, we correlated the preference scores of our 201 S's with the possession or lack of

TABLE 18
CORRELATION BETWEEN TOTAL HAND-PREFERENCE SCORE AND
THE POSSESSION OF LEFT-HANDED RELATIVES

Relative	Correlation coefficient
Parent	.097±.078
Sib	.015±.075
Grandparent	.172±.091

TABLE 19
PERCENTAGE OF "LEFT-HANDED" AND "RIGHT-HANDED" SUB-
JECTS (CLASSIFIED ACCORDING TO PERFORMANCE ON TWENTY
SELECTED ITEMS) WHO REPORT LEFT-HANDED
RELATIVES

Group	Relative			
	Father	Mother	Sib	Grandparent
Left-handed	6.7±4.4	20.0±6.9	26.7±7.7	6.7±4.4
Right-handed	4.8±1.1	4.8±1.1	17.2±1.9	4.8±1.1

possession of a parent reputed to be left-handed, a grandparent, or a sib. These correlations we likewise found unimposing. (See Table 18.)

Frequency of Left-handed Relatives in Right- and Left-handed Groups. Our last approach to the question was an investigation of the incidence in our so-called right-handed and left-handed groups,³ of individuals who reported a left-handed parent, sib, or grandparent. In all of these comparisons it appears that the left-handed group has a somewhat higher percentage of left-handed relatives than does the right-handed, the difference being considerable, however, only in the case of the mother. Even here it is not

³These were the individuals whose scores fell in the right and left mode of the distribution based upon the 20 selected items.

worthy of much confidence, perhaps again because of the small number of left-handed S's. (See Table 19.) It should be mentioned that other workers who have had access to a larger number of S's have found some family resemblance (3).

The findings resulting from our work on family resemblance, then, point only slightly, if at all, in the direction of genetic influences. These, if they exist, seem related more to the fact of bimodality in certain distributions than to the general fact of dispersion.

V

RELATION OF MANUAL CHOICE TO SIDE PREFERENCE IN OTHER BODY MEMBERS

Nature of Types. If genetic or fundamental organismal factors are influential, it will be interesting to consider whether these are many or relatively limited. An investigation of the relation between hand preference and performance with other parts of the body, it was hoped, might illuminate the question somewhat. In other words, we should like to know whether, when the right hand is preferred, all other right body members are preferred also; and, more significant still, whether the latter are more efficient than the left.

The adjustments chosen for consideration were in some cases primarily motor; in others, sensory. In some, the hand is involved in a phase of the reaction; in others, it is not.

Side Preferred for Sleeping. One of the body adjustments involving a choice of side that is believed by some to be related causally to manual choice is sleeping-posture. It has been claimed that the hand free most of the time during sleep in infancy is exercised more than the other and hence comes to dominate. Sidis (15), on the other hand, believed that the sleeping-side and the side on which the preferred hand is found coincide. Boynton and Goodenough's (2) study of the naps of preschool children offers evidence which corroborates the first point of view and is not concurrent with Sidis'.

In the light of this disagreement, although we were aware that the side favored during childhood may not be the one favored in adulthood, the question of the relation in adulthood between preferred hand and the side upon which most of the individual's rest is taken seemed worthy of consideration.

We are conscious also of another difficulty in our procedure, namely, inaccuracy in report. Johnson (8), for example, argues cogently that individuals know relatively little of their postures during sleep. While emphasizing, however, the fact of frequent alteration of position during sleep, he does admit that more time is usually spent on one side than on the other. Boynton and Goodenough (2) also found this to be true. Neither author, unfortunately, has given us data bearing on the question of the incidence of correct judgment in regard to posture favored in sleep.

Although the 50 S's taking part in our experiment on test reliability reported their sleep-posture preference entirely consistently in the two questionnaires, the product-moment r 's between total hand-preference scores and the side reported as preferred for sleep is only $+0.144$ and hence probably insignificant.

When, however, the habits of our so-called right- and left-handed groups are compared, it appears that about three times as many, relatively speaking, of the latter as of the former aver that they spend more time on their left sides when sleeping. The reverse obtains for the right-handed group. Hence, our findings are not in accord with those of Goodenough and Boynton. Since their study was concerned with the relative

TABLE 20
RELATION TO MANUAL PREFERENCE OF NON-MANUAL SIDE PREFERENCES OF VARIOUS
SORTS—CORRELATIONS AND EXTREME-GROUP DIFFERENCES

	Pearson product- moment cor- relation coefficient with total hand-pref- erence score	Percentage of right- handed group favoring right side	Percentage of left- handed group favoring right side	Percentage of right- handed group favoring left side	Percentage of left- handed group favoring left side	Percentage of agreement between first and second per- formance test (50 cases)
Adjustment						
Shoulder used for resting bat	+ .518	96.8	46.7	5.2	53.3	100
Direction in which pirouette is made	+ .140	71.0	60.0	29.0	40.0	73
Sighting eye in ring test		45.7 (26.8)*	33.3	25.9	66.7	56.84
Foot and leg most efficient in balanc- ing	+ .086	54.3	53.3	45.7	46.7	80
Side preferred for sleeping†	+ .144	79.1	26.7	20.9	73.3	98
Leg uppermost when legs are crossed	+ .255	71.5	53.3	28.5	46.7	82
Shoulder upon which gun is rested	+ .559	97.8	40.0	2.2	60.0	100
Direction in which tongue is rolled	— .290	66.7	86.7	33.3	15.3	64
Jaw used for biting a peanut	+ .466	80.1	20.0	19.9	80.0	74
Direction in which head is turned when listen- ing for watch-tick	+ .261	61.9	26.7	38.1	73.3	80
Direction of hand- strength difference	+ .377	91.7	26.6	8.3	60.0	90
Eye used for sighting in microscope	+ .241	74.2	20.0	25.8	80.0	86

*The percentage in parentheses is that for the S's who favored the right eye part of the time only.

†The S was merely questioned in regard to the side preferred for sleeping.

amount of time spent by preschool children in various sleep-postures and ours was a questionnaire study of adults' sleep-posture preference, we may find here the reason for the divergence in results. Perhaps our findings show a sort of halo effect, i.e., our S's may think they favor a certain side for sleeping merely because they are so vividly aware of their manual preference.

Relative Strength of the Two Hands. Since, after all, sleeping-posture is alleged to influence manual preference in part through its effect on arm strength, we may get evidence that will aid us in interpreting our results by considering the relation between manual preference and strength.

If differences in strength are either the cause or effect of manual preference, it would be reasonable to expect a fair-sized correlation between relative difference in physical strength and relative strength of hand preference. These coefficients, however, are found to be practically negligible. (See Table 21.) Since the

TABLE 21
CORRELATIONS BETWEEN THE DEGREE OF RIGHT- OR LEFT-HAND
PREFERENCE AND THE RELATIVE DIFFERENCE IN STRENGTH
OF THE TWO HANDS—FIRST PERFORMANCE TEST

Type of manipulation	Right hand the stronger	Left hand the stronger
Bimanual taught	$+.029 \pm .051$	$+.082 \pm .134$
Bimanual untaught	$-.004 \pm .051$	$-.098 \pm .133$
Bimanual total	$+.001 \pm .052$	$-.025 \pm .135$
Unimanual taught	$-.069 \pm .051$	$+.071 \pm .134$
Unimanual untaught—equal opportunity	$-.041 \pm .051$	$+.074 \pm .134$
Unimanual untaught—handicap offered	$-.001 \pm .051$	$+.070 \pm .134$
Unimanual total	$-.041 \pm .051$	$+.074 \pm .134$
Hand preference total	$-.050 \pm .051$	$+.015 \pm .134$

results of the two performance tests tend to agree at least 90% of the time in regard to the direction of the difference in manual strength and since the product-moment correlations between degree of hand-preference scores and the direction of strength difference are also relatively high, it is probable that one cause of the low correlations under discussion lies in the fact that our measure of relative strength is not sufficiently accurate to be very valuable. This hypothesis is supported by the observation that the correlation of the ranks of the 50 S's in the two performances according to the relative differences in the strength of their hands is only $+.58 \pm .06$. Correcting our coefficients for attenuation in the light of this, does not, however, make them significant.

Our strength tests were given with a Smedley dynamometer and the measures used were the averages of only three trials. A longer series of trials probably would have been desirable, especially since the manner of gripping the dynamometer, the interest of the S, and the previous activity of his hands, etc., are factors which might operate to obscure the actual *degree* of the relative difference in strength in the two hands.

It is interesting that in our so-called left-handed group 60% showed the left hand to be the stronger, while in the right-handed, the corresponding percentage was 8.3. Superior strength in the right hand was shown in the two groups in, respectively, 26.6 and 91.7% of the cases; and equal strength in 6.7 and 3.9%.

Although our results, then, do not support the doctrine that the side of the body on which the strongest

hand is found is the reverse of that believed to be favored for rest, the direction of hand-strength difference and hand preference do seem to be related.

Jaw Preference. Believing, since feeding plays so important a rôle in the life of the organism, that if one side of the face functioned more efficiently than the other in this process, this might be a factor influencing hand choice, we noted what jaw the S's used in cracking a peanut shell. Of course, since the test is one of jaw preference rather than efficiency, all that we may conclude is that jaw and manual choice do or do not agree. Hand choice, we are well aware, may influence choice of jaw as well as vice versa. Hence, of the direction of the relationship, if there is only one, we can state nothing definitely.

There seems to be a strong relationship between the favored jaw and hand, according to the correlations in Table 20, which are based upon our total group of S's. This is surprising, since the same jaw was chosen in the two performance tests only 74% of the time.

It is noteworthy that the peanut-cracking situation is one of the three in Part V that best differentiate the so-called left- from the right-handed group. Eighty per cent of the left-handed employed their left jaws, whereas 20% of the right-handed did so. The reverse obtains for those using the right jaw. As has been suggested, these findings may be explained by an influence which radiates from hand to jaw rather than vice versa.

Tongue Rolling. The results regarding the preferred jaw are in contrast to those of the tongue-rolling

test, in which slightly more, relatively speaking, of the so-called left-handed rolled their tongues to the right than did the right-handed. In the two performance tests the direction in which the tongue was rolled was the same only 64% of the time. Hence, we are dealing here with a rather unstable type of adjustment.

The test was included because it has been alleged that the direction preferred for movement tends to correspond with the preferred side. In the case of the tongue, moreover, no instruction would have been received and the possibility of specific manual influences, as in the previously described test, would have been eliminated.

Gun and Bat Shoulder. The shoulder upon which a gun or bat is rested is chosen very consistently, if the results of our two performance tests are to be relied upon. The preferred shoulder, too, tends to agree with the side preferred in manual operations. Both the correlations and the extreme-group comparisons support this generalization. Again we may question whether the choice of hand does not influence the choice of shoulder, rather than vice versa.

Leg Uppermost. The possibility of direct manual influences, such as mars the preceding test, is probably not a consideration in the results of our observations on the leg which tends to be uppermost when the legs are crossed as the S adopts a sitting posture. The tendency for that leg to be uppermost which is on the side of the favored hand is somewhat greater than the tendency for the thumb on that side to be uppermost when the hands are clasped. Both the correlations and ex-

treme-group comparisons reveal the same trend. It is noteworthy that the relationship between favored leg and hand, however, is considerably less than that apparent in the case of the favored shoulder. The fact that the leg uppermost in the two performance tests is the same in 82% of the cases suggests that the leg-crossing habit is rather stable.

Balancing Test. Since it is difficult to affix a functional significance to the leg-uppermost adjustment, it seemed well to check on the theory that the preferred hand tends to correspond as to side with the foot which offers the best support. We attempted to determine the foot which renders best support by noting how long the S's could stand on the toes of their right and left feet. Since the returns of the two performance tests show 84% agreement, it is probable that the low correlations between the results of the balancing test and our measures of strength of hand preference validly express little or no relationship between these variables.

Direction of a Pirouette. The direction in which a pirouette tends to be made—an adjustment probably little influenced by instruction and direct manual factors—seems practically unrelated to hand preference. The adjustment, moreover, either is not very stable, as a comparison of our two performance tests indicates, or else an adequate sampling of behavior was not made.

The test was included because some authors have asserted that animals tend to prefer to turn toward one side rather than the other and consider this as evidence for the theory that hand preference is only an expression of side dominance which appears in most phyla.

Ear Preference. Sense-organ preference or relative efficiency has been studied more frequently in relation to manual choice than have the less restrictedly sensory activities. Many have sought in the former the cause of manual preference, while others see in any correlation that exists evidence for the theory of a dominant hemisphere.

In our ear-preference test, we would make it clear, no watch was employed, as might be inferred from the questionnaire. The S was simply told that he was to listen for the ticking of a watch which would be very faint, and that he might move his head, if he chose, in order to hear better. The E then took a position at some distance directly back of the S and observed the direction in which the S's head was first turned. While we tried to control the influence of body set and suggestion through the direction from which the E took his position, it is questionable whether we succeeded entirely. The percentage of agreement between the two performance tests is 80.

The head-turning test was supplemented by an audiometer test designed to reveal the relative acuity of the two ears. The S's here listened in a group with the aid of head phones to several phonograph records standardized and scaled to test acuity. The audiometer test was given to a class of about 22 students at one time. Two classes acted as S's. It should be remembered that the test depends for its success upon perfect quiet in the school room—a condition difficult to obtain—as well as upon the sustained interest and attention of the S's.

TABLE 22
NUMBER, AMONG 43 CASES, OF AGREEMENTS AND DISAGREEMENTS
BETWEEN ACUITY AND EAR-PREFERENCE TESTS

Comparison	Test			
	P ₁	P ₂	Q ₁	Q ₂
Number of agreements	33	35	31	33
Number of disagreements	10	8	12	

The agreements of the audiometer test and our head-turning test are given in Table 22. Since the head-turning test forces a choice, whereas in the case of the acuity test an equal rating for the two ears is possible, only when the latter revealed an auditory difference contrary to the latter is failure of preference and acuity to agree reported.

It appears from Table 22 that about one-fourth of the time, when the audiometer-test results indicated differences in aural acuity, the head-turning test revealed a preference for the less acute ear. The disagreements occurred, in all but two cases, when the audiometer results showed but one scale-interval divergence in the rating of the two ears. Of the nine cases, moreover, which performed differently in the two listening situations, three have, according to the audiometer-test results, ears which are equally acute; and in no case did the acuity ratings for the two ears differ by more than one scale interval. Hence, aural acuity and preference seem to be somewhat closely related.

The lack of closer agreement between the findings of the listening and acuity test may be interpreted in terms (1) of the failure of acuity and preference al-

ways to coincide, (2) of the crudities of the two tests employed, (3) of the inadequacy of a single sample of behavior as a representative of auditory choices, or (4) of the instability of preference in some people. For each of these hypotheses there is some evidence.

In the light of the relationship disclosed between acuity and the posture adopted for listening, it is significant that the direction in which the head is turned when making difficult auditory discriminations tends to be related to a fair degree to the side of the preferred hand, whereas aural acuity (see Table 23) seems to be related very slightly or not at all. This suggests that hand preference influences ear preference rather than the reverse.

Tests of Eye Dominance. The eye-dominance test was included because of a theory popularized by Parsons (14) that eye dominance is a major determinant of hand dominance. The ring test was used not only because of the ease of administering it to a group but also because we wished to adopt a procedure similar to that employed by other workers, Downey being one. With such techniques as Mile's A. B. C. test or Cuff's manoptometer we were not familiar at the time the experiment was in progress.

A second form of sighting test, namely, that of looking through a small microscope, was given because of our suspicion that the eye preferred for a task may be a function of many details in the situation. The microscope situation is, moreover, more nearly a preference situation than is the ring-sighting situation. In the use of the microscope, for example, the S is aware he

TABLE 23

DISTRIBUTION AND AVERAGES OF HAND-PREFERENCE SCORES
BASED ON SELECTED AND UNSELECTED ITEMS, OF INDIVIDUALS
WHO ACCORDING TO THE LISTENING AND ACUITY TESTS
FAVORED THE RIGHT OR THE LEFT EAR

Hand- preference score	Unselected items					Selected items				
	Ear most sensitive		Direction of head turn in listening			Ear most sensitive			Direction of head turn in listening	
	Right	Left	Equal	Right	Left	Right	Left	Equal	Right	Left
100						5	10	7	18	8
95-99						3	5	4	7	7
90-94	1		3	3			1	1	2	
85-89	2	4	1	5	2	1		1		2
80-84	4	6	5	10	8					
75-79	2	2	2	5	4					
70-74	1	3		2	2					
65-69			1		1					
60-64			1							
55-59				1				1	1	
50-54			1	1						
45-49				1	1					
40-44			1							
35-39					1					2
30-34					1			1		1
25-29			1		1					
20-24										
15-19										
10-14		1			1			1		1
5-9							1			1
0-4										
Mean score	82.5	76.9	72.5	80.2	70.2	97.7	93.4	85.8	97.3	81.1
Sigma of distribu- tion				12.3	21.4				8.2	32.4
Probable error of mean				1.5	3.0				1.0	4.6

is choosing a certain eye for sighting, whereas few S's were conscious of sighting with only one eye through the ring, until the test revealed this fact to them.

Our returns from the ring test support Mile's (10)

findings to the extent of indicating similar proportions of the clearly right- and left-eyed people. Of our S's 95 (47.3%) seemed to use their right eyes, 54 (26.8%) their left, and 52 (25.9%) reported behavior that suggested they used a different eye in the two trials of the test. Of the group sighting consistently right or left, 35.3% sighted left and 64.7% right. The large number stating that they used different eyes in the two trials of the test is probably to be expected because of the possibility of the employment of different hands in the two trials as well as the possibility of inaccuracy of report. Downey makes much of the latter point, as even her group of American psychologists had difficulty in escaping a right-left confusion. Although we warned our S's at length concerning the necessity of an accurate statement of what happened and answered their questions concerning procedure while the test was in progress, our two performance tests show only 56% total agreement and 28% more of partial agreement.

The microscope test, which according to our returns called out the same response more consistently than did the ring test, likewise confirms our suspicion that the eye selected for sighting varies with a number of circumstances, for here the number of S's using the left eye was 60, whereas the number using the right was 141. In view of these figures, it is interesting that when the group sighting consistently with the right eye in the ring test is combined with the group sighting with the right eye not so uniformly, the S's number 135, i.e., are about equal in frequency to those using the

right eye in the microscope test. Perhaps the microscope situation in forcing a more obvious choice reduces that variability in the choice of eye which characterizes the ring test.

The eye used in sighting through a ring is an index which differentiates between the so-called right- and left-handed groups fairly successfully, i.e., slightly less well than does the ear-preference test, while the microscope test differentiates between the two groups somewhat better than does the latter index. But certain it is, since our results find corroboration elsewhere (4, p. 172), that there is no perfect relationship, as Parsons (14) believes, between eye dominance and hand preference. Nor were we able to gather from the responses to our questions concerning accidents to eyes or hands data that would account for the failure of the dominant hand and eye to coincide as to side more frequently than they did. Of the 53 S's in our total group who showed consistent disagreement between eye and hand dominance, 73.6% claimed that they (1) had escaped eye disorders, (2) were unaware of experiences that would favor one eye more than the other, and (3) were never victims of temporarily incapacitating accidents to their arms or hands. (See Table 24.) Only 11.3% mentioned having or having had difficulties in one of their two eyes and of such a nature as to be usable for explaining the failure of eye and hand preference to correlate. About 23% more reported having or having had difficulty with both eyes, while 7.6% indicated they had had accidents which prevented them from using a hand or

TABLE 24
FREQUENCY OF EYE-HAND-PREFERENCE AGREEMENT IN RELATION TO EYE DISORDERS, ACCIDENTS TO HANDS
OR ARMS, AND SPEECH DIFFICULTIES

Groups based on eye- and hand-preference agreement	Greater speech-difficulty group		Small speech-difficulty group		Speech groups		No speech-difficulty group		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Group I. Preferred eye and hand do not consistently agree as to side	21	23.6±3.0	11	26.8±4.7	32	28.4±2.9	53	26.4±2.1		
Frequency of S's having accidents to hands	0	0.0	0	0.0	4	12.5±4.0	4	7.6±2.4		
Frequency of S's having eye disorders in both eyes	6	28.6	3	27.3	6	18.3±4.6	12	22.6±3.8		
Frequency of S's having significant eye disorders in one eye	3	14.3	0	0.0	3	9.4±3.4	6	11.5±3.0		
Frequency in Group I of S's having no eye disorders or accidents to hands	12	57.1	8	72.7	17	53.1±5.9	39	73.6±4.1		
Group II. Preferred eye and hand seem to agree partially as to side	26	29.2±5.2	8	19.5±4.2	25	23.3±2.7	51	25.3±2.1		
Frequency of S's having accidents to hands	2	7.7±3.4	0	0.0	4	16.0±4.9	6	11.8±3.1		
Frequency of S's having eye disorders in both eyes	2	7.7±3.4	2	25.0	6	24.0±5.7	8	15.7±3.5		
Frequency of S's having significant eye disorders in one eye	4	15.4±4.7	1	12.5	3	12.0±4.4	7	13.7±3.3		
Frequency of S's having no eye disorders or accidents to hands	17	65.4±5.3	4	50.0	13	52.3±6.7	30	58.8±4.7		
Group III. Consistent agreement as to side of eye and hand preference	42	47.2±3.6	22	53.7±5.5	55	49.1±3.2	97	48.2±2.4		
Frequency of S's having no eye disorders or hand accidents	24	57.1±5.1	11	50.0	32	58.2±4.5	56	57.7±3.4		

TABLE 25
 FREQUENCY IN SPEECH AND EYE-HAND-PREFERENCE-AGREEMENT GROUPS OF SUBJECTS CLAIM-
 ING FREQUENT CONFUSION IN AT LEAST ONE OF THREE SITUATIONS—DRIVING A CAR,
 MILITARY DRILL, WAITING ON TABLE

Speech groups	Groups based on agreement or disagreement in eye and hand preference				Eye and hand preference			
	Eye and hand preference disagree consistently as to side		Eye and hand preference agree partially as to side		Eye and hand preference agree consistently as to side		Eye and hand preference agree consistently as to side	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
Greater speech-difficulty group	13	61.9 ± 6.7	6	23.1 ± 5.8	9	21.4 ± 4.2		
Small speech-difficulty group	7	63.6	4	50.0	6	27.3		
No speech-difficulty group	8	25.0 ± 5.2	3	12.0	13	23.6 ± 3.9		
Total	21	39.6 ± 4.6	9	17.3 ± 3.6	22	22.7 ± 2.8		

TABLE 26
 FREQUENCY FOR THE GROUP AND FOR AN INDIVIDUAL IN SPEECH AND EYE-HAND-PREFERENCE-
 AGREEMENT GROUPS OF SITUATIONS CLAIMED BY S'S TO BE FREQUENTLY CONFUSING AS
 FAR AS THE RIGHT-LEFT DISCRIMINATIONS INVOLVED ARE CONCERNED

Speech groups	Groups based on agreement or disagreement in eye and hand preference					
	Eye and hand preference disagree consistently as to side	Eye and hand preference agree consistently as to side	Eye and hand preference disagree partially as to side	Eye and hand preference agree partially as to side	Eye and hand preference disagree consistently as to side	Eye and hand preference agree consistently as to side
	Number of situations for an individual	Number of situations for an individual	Number of situations for an individual	Number of situations for an individual	Number of situations for an individual	Number of situations for an individual
Greater speech-difficulty group	23	1.1	11	.43	10	.34
Small speech-difficulty group	11	1.0	7	.88	7	.52
No speech-difficulty group	10	.31	8	.52	16	.29
Total	33	.62	19	.37	26	.27

TABLE 27
FREQUENCY IN SPEECH AND EYE-HAND-PREFERENCE-AGREEMENT GROUPS OF S'S WHO LEARNED TO DIFFERENTIATE RIGHT FROM LEFT BY VARIOUS METHODS

	Greater speech-difficulty group				Small speech-difficulty group				No speech-difficulty group				Total	
	Direct apprehension	Kinaesthetic cue	Arbitrary visual cue	Arbitrary visual cue	Direct apprehension	Kinaesthetic cue	Arbitrary visual cue	Arbitrary visual cue	Direct apprehension	Kinaesthetic cue	Arbitrary visual cue	Arbitrary visual cue	Direct apprehension	Arbitrary visual cue
Groups based on extent of agreement or disagreement between eye and hand preference														
Number of group with consistent disagreement between eye and hand preference	5	11	5	1	7	3	3	9	21	2	14	32	7	7
Percentage of group with consistent disagreement between eye and hand preference	23.8	52.4	23.8	9.1	63.6	27.3	28.1	55.3	65.6	6.3	28.4	60.4	13.2	3.1
Number of group with partial agreement between eye and hand preference	6	19	1	2	5	1	4	16	3	10	27	4	4	4
Percentage of group with partial agreement between eye and hand preference	23.1	71.1	3.8	25.0	62.5	12.5	16.0	44.9	72.0	12.0	19.5	74.6	7.8	2.6
Number of group with consistent agreement between eye and hand preference	12	23	2	6	15	1	14	36	5	26	64	7	7	7
Percentage of group with consistent agreement between eye and hand preference	28.6	66.7	4.8	27.3	68.2	4.6	25.5	44.0	65.5	9.1	26.8	66.0	7.2	1.8
Total number	23	53	8	9	27	5	27	75	10	50	133	18	18	18
Percentage of total	25.8	62.2	9.0	21.9	65.9	12.2	24.1	41.0	68.0	8.9	24.9	66.2	8.9	1.3

an arm for a period of two weeks or longer. For the 51 S's exhibiting partial disagreement between hand and eye preference, i.e., the sighting tests did not give entirely uniform results, the four percentages corresponding to those just enumerated are, respectively, 58.8, 13.7, 15.7, and 11.8. (See Table 24.)

It is worthy of note that of the S's in whom hand and eye dominance seemed not to be in accord 39.6 \pm 4.6% mentioned being frequently confused when discriminating between right and left in at least one of the three situations described in the questionnaire, while for the groups for whom the agreement as to side of sighting eye and preferred hand was entirely or partially consistent, the corresponding percentages are, respectively, 22.7 \pm 2.8 and 17.3 \pm 3.6. (See Table 25.) If a comparison is made between the number of times confusion in right-left orientations is mentioned on the average per individual in the three groups just enumerated the figures are found to be .62, .37, and .27, respectively. (See Table 26.) It is interesting, too, even though the group differences are not sufficiently large to indicate great probability of validity, that the S's exhibiting disagreement between eye and hand preference claim more frequently that they depended on artificial or arbitrary visual cues when learning to identify right and left than did the others. (See Table 27.)

VI

MISCELLANEOUS VARIABLES

Speech Disorders. A question which has commanded more attention than even that of the relation between eye and hand dominance is that of the relation between speech irregularities and manual experience. This issue we have given some attention. With respect to the questionnaire method of investigating speech difficulties which we used we have already expressed our dissatisfaction. We felt, however, that, if a strong relationship existed between disordered speech and certain manual characteristics, this might be revealed by even so crude an instrument as the questionnaire.

Forty-one of our S's mentioned a difficulty such as stammering, lisping, and hesitation, etc., while this number was increased to 89 by those claiming that they learned to talk at an age which according to Gesell's standard would indicate that their speech development had been somewhat retarded. Too many of our S's, then, it appears, have tested themselves by too severe a standard or have inaccurate notions regarding their speech development; but if one contrasts the groups which we have designated as the Greater Speech-Difficulty Group (89 cases) and the Small Speech-Difficulty Group (41 cases) with the group reporting no speech problems, the former two, and especially the latter, should at least be weighted with cases having real speech disorders.

Between the groups who do and do not report speech

TABLE 28
SPEECH DIFFICULTIES IN RELATION TO ALLEGED LEFT-HANDEDNESS, CORRECTION OF ALLEGED
LEFT-HANDEDNESS, AND PREFERENCE STRENGTH SCORES OF MEDIUM DEGREE

Quality compared	Greater speech- difficulty	Speech groups Small speech- difficulty	No speech- difficulty
Number of cases	39	41	112
Number trained to use the right hand	11	6	10
Percentage trained to use the right hand	12.4 ± 2.4	14.6 ± 3.8	8.9 ± 1.9
Number who alleged themselves to be left- handed when the test was taken	7	3	8
Percentage of group who alleged themselves to be left-handed when the test was taken	7.9 ± 2.0	7.3 ± 2.7	7.1 ± 1.7
Number who alleged they were at some time in their lives left-handed	13	8	12
Percentage of group who alleged they were at some time in their lives left-handed	14.6 ± 2.5	19.5 ± 4.2	10.7 ± 2.0
Number with total hand-preference scores between +0 and 74	14	10	26
Percentage of group with total hand- preference scores between +0 and 74	15.7 ± 2.6	24.4 ± 4.3	23.2 ± 2.7

problems, no reliable differences appear with respect to the relative frequency of individuals alleging themselves (1) to be left-handed at the time of taking the test or to have been at any time previous, or (2) to have had training in the use of the right hand. The incidence of hand-preference scores of medium (40-74) grade in the groups is also not grossly at variance. (See Table 28.) It is worthy of comment, though, that the Small Speech-Difficulty Group, the group probably having in it the largest number of bona fide speech cases, has a slightly higher number of members who indicated that, having once been left-handed, they had been trained to use their right hand. Considering the probable weighting of our speech-difficulty groups by a large number of non-speech cases, we may with some reason suspect the aforementioned difference of being valid.

Interestingly enough, the incidence of speech dis-

TABLE 29
RATIOS OF THE DIFFERENCES BETWEEN THE MEAN SCORES MADE
BY THE MEN AND WOMEN AND THE PROBABLE ERRORS OF
THESE DIFFERENCES—FIRST PERFORMANCE TEST
AND FIRST QUESTIONNAIRE

Types of manipulation	First performance test	First question- naire
<i>Bimanual taught</i>	.27	.00
<i>Bimanual untaught</i>	2.39	1.42
<i>Bimanual total</i>	.92	1.40
<i>Unimanual taught</i>	.46	.62
<i>Unimanual untaught—equal opportunity</i>	.14	1.20
<i>Unimanual untaught—handicap offered</i>	4.89	2.96
<i>Unimanual total</i>	2.92	1.14
<i>Hand preference total</i>	2.71	.66

orders seems to be significantly greater in the groups showing both the failure of eye and hand preference to be in accord as to side, and frequent confusion in right-left discriminations. (See Table 25.) Mere absence of agreement in hand and eye preference does not seem to distinguish the groups reporting and not reporting speech disorders. Since this is true, the spatial confusion rather than the lack of coincidence as to side of manual and ocular dominance seems to be the relationship of significance in speech difficulties. Whether both conditions are an expression of the same influences or are causally related is a question.

Sex Differences. Still another one of the variables with which strength of hand preference is supposed to vary is sex. Our results, both for the selected and unselected items, reveal no reliable sex difference. (See Tables 5, 29, and 30.) It is interesting that our findings are somewhat out of line with those of Jones (9, p. 143) who found the boys in his sample of preschool children to have a lower dextrality index on the average than the girls.

The questionnaire indicates essentially the same trends as the performance test. There is, furthermore, no evidence that the men are better judges or predictors of their manual behavior than are the women. The variability in the performance of our group of men is less than that appearing in the group of women; but we are inclined to doubt whether this indicates a valid sex difference, since our male S's were relatively few in number.

College Major. The assertion is common that in-

TABLE 30
MEANS, SIGMAS OF DISTRIBUTIONS, AND SIGMAS OF MEANS FOR
SEX AND ACADEMIC GROUPS—SCORES BASED
ON TWENTY SELECTED ITEMS

Groups	Mean	Sigma of dis- tribution	Probable error of mean
Female	90.65	21.70	1.19
Male	92.45	17.85	1.63
Social science	88.90	20.30	1.48
Literature and arts	93.00	10.75	1.61
Business administration	96.37	6.25	.82
Science	90.56	18.15	2.33
Total	93.64	20.60	.97

dividuals who possess various manual biases gravitate into fields of work favorable to their propensities. In the face of such assertions it seemed of value to investigate the preference trends of those students in our groups majoring in four fields of academic work—the social sciences, literature and arts, business administration, and the physical or biological sciences. These, we recognize, are academic divisions and perhaps are not the most useful ones that might be devised. Unfortunately, moreover, the frequencies in some of these groups are low and the proportion of the two sexes not the same. Since we have found no marked sex difference, the latter consideration does not, however, seem important. (See Tables 30, 31, and 32.)

It appears that the students majoring in arts and literature have a consistently stronger right preference than those majoring in the social sciences, although the differences are not large and in only one case meet the usual statistical standard of reliability. Since sev-

TABLE 32
RATIOS OF THE DIFFERENCES BETWEEN THE SCORES MADE BY STUDENTS MAJORING IN VARIOUS
ACADEMIC FIELDS AND THE PROBABLE ERRORS OF THESE DIFFERENCES—FIRST
PERFORMANCE TEST

Type of manipulation	Social science and liter- ature and arts	Social science and business administration	Groups compared			
			Social science and science	Literature and arts and busi- ness admin- istration	Literature and arts and science	Business administra- tion and science
Bimanual taught	1.91	2.77	1.20	1.11	.01	.98
Bimanual untaught	3.07	2.38	.43	.18	2.93	2.42
Bimanual total	2.69	2.60	.02	.33	1.92	1.99
Unimanual taught	.73	3.25	.01	2.23	.64	2.10
Unimanual untaught— equal opportunity	2.57	3.44	.01	.64	1.92	2.43
Unimanual untaught— handicap offered	.67	1.18	2.67	1.49	3.11	1.55
Unimanual total	1.78	1.51	1.11	.19	2.42	2.22
Hand preference total	2.35	2.18	1.22	.01	2.89	2.79

eral of the ratios in Table 31 are well over 2, the differences are all in one direction, and the existing differences in the proportions of the two sexes probably inconsequential, the general trend may merit some attention. There may, of course, have been other factors effective in coloring our samples of each of these academic groups but of these we were not aware.

The science students, who are unfortunately few in number, in contrast to the others, do not differ conspicuously from the social science group in the strength of their preference for the right hand.

The other possible group comparisons, as one might expect, reveal the following relationships; the business administration and literature and arts students differ little; the literature and arts group tend to be more strongly right-handed than the science; and the business administration majors tend to favor the right hand more than do the science.

If our results are more than the products of accidental factors, they furnish material for interesting speculations. The science and social science students one might surmise to be more practical-minded and more intimately acquainted with a wider range of the physical concretes of the world than the business (executive and clerical) or literature and arts devotees. Wide manual experience, it is assumed, would make for greater variety in manual choice. The social science group, likewise, may be more interested practically in people and their ways and hence could be expected to have had more varied experience with the

concrete world than the commerce or humanities majors.

One can, of course, as convincingly argue that students have entered such academic divisions as give them with their native manual biases an advantage.

VII

SUMMARY AND CONCLUSIONS

The manual choices in 105 situations of 201 university students were studied by means of observations of actual behavior and by means of a questionnaire paralleling these observations. The tasks the S's were called upon to perform were generally of the sort with which people have daily contact. Some of the tasks required the use of only one hand, some the use of two. In certain ones the S had probably received instruction at one time or another with respect to the commonly accepted manual choice; in others, it was probable he had not. Usually the S was required to pick up the object to be manipulated, the latter being placed directly in front of him. The S was confronted with certain tasks, however, in which each hand was offered a position handicap and then a position advantage. The tasks were grouped into five sections according to the qualities just described. The sections were arbitrarily designated as follows: "bimanual taught," "bimanual untaught," "unimanual taught," "unimanual untaught—equal opportunity," and "unimanual untaught—handicap offered."

Among the major findings of the investigation are the following:

1. Correlating the scores based on odd and even items reveals the fact that the various sections of the performance test are to a high degree homogeneous. The bimanual untaught activities, however, yield sig-

nificantly lower correlations than do the other activities.

2. The correlations between the five parts of the performance test range from $+.386$ to $+.881$, being considerably less than those obtained by the odd-even item method. Scores for the unimanual section in which the position handicap and advantage were offered correlate least with the scores on the other sections, whereas those groups of unimanual tasks designated "taught" and "untaught" which afforded both hands equal opportunity to perform show the closest relationship to each other.

Partial correlations indicate that the sections labelled "taught" have something in common not present in the other sections. The same statement might be made for the sections designated "untaught," unimanual, and bimanual. The tasks involving the position handicap seem to contribute to the performance test little, if anything, that is not included in the other divisions.

4. The selection of the right hand to dominate in an adjustment tends to occur more frequently in the unimanual than in the bimanual series; in the "taught" than in the "untaught."

5. Two performance tests separated by an interval of four weeks were taken by 50 S's. Scores made in the two performance tests on corresponding sections correlate above $.90$, with the exception of the section designated "bimanual untaught," which had a reliability coefficient of $+.879$. For the handicap series the reliability coefficient was $+.950$ and for the total series of tasks $+.925$.

6. A study of the agreement of the manual choices in the individual tasks of the two performance tests indicates that 3 to 14.8% of the time, depending on the section, a different hand was selected to direct the operation.

7. Evaluation of individual items by a correlation and extreme-group comparison method reveals that the tasks vary greatly as far as their predictive value with respect to performance in tasks of various types is concerned. Several of the indices which have been used frequently-- indices such as the position of the hands on the handle of the broom in sweeping or the thumb uppermost when the hands are clasped-- appear to be among the least satisfactory of our tests for prediction. Activities which may be described as carrying are, likewise, among those which are unsatisfactory, as are also most of the tasks in the handicap series. The more elaborate and delicate adjustments seem to have the greatest index value, other things being equal. Neither the position handicap nor advantage appears to influence consistently the size of the items' correlations with the section or total scores.

8. The questionnaire correlates well with the performance test and is reliable as far as total section scores are concerned. Responses to the questionnaire and actual performance tend to agree 76 to 94% of the time, depending on the group of tasks considered. The S's generally do not tend to report themselves more strongly right-handed than the performance tests indicate. The S's probable reaction to particular situations seems to be more consistently reported for the

unimanual than the bimanual series; for the "taught" than the "untaught."

9. Suggestions of bimodality in the distributions of section and total scores are slight. However, the distribution of scores based upon the 20 items which correlate best with the section and total scores exhibits a clear-cut bimodality. About 6% of the total group of S's fall within the range of the lower or left mode in this distribution.

10. While the correlations between the hand-preference scores of sibs are insignificant as are also the correlations for all S's between hand-preference scores and the possession of left-handed relatives of the degree of parent, sib, or grandparent, the individuals whose scores on 20 selected items fall in the left mode seem to have more left-handed relatives, especially parents, than do the individuals whose scores fall in the right mode. Even the group differences, however, while consistent, are not sufficiently large to merit considerable faith.

11. Measures of the relative difference in the strength of the two hands do not yield significant correlations with measures of strength of hand preference based on the total series of 105 tasks. The measures of relative difference in hand strength are not, however, very reliable. The *direction* of hand-strength difference does correlate well with hand-preference scores and differentiate well between the so-called right- and left-handed groups.

12. The side upon which the S's reported that they prefer to sleep tends to correspond to that on which the preferred hand is found.

13. The jaw preferred for biting and the shoulder upon which a gun or bat is rested tend to coincide as to side with the preferred hand. A slight tendency to correspondence with the favored hand as to side is also found for that leg which is uppermost when the individual sits with his legs crossed.

14. Unrelated to the side of the preferred hand seems to be the direction in which the S tends to roll his tongue, the leg on which the S can stand the longest when balancing himself on his toes, and the direction in which he tends to pirouette. The first and third of these tests are not very reliable.

15. The direction in which the head is turned when the S is straining to hear tends to be toward the side of the favored hand, whereas the relative acuity of the two ears seems unrelated to hand preference.

16. Sighting a distant object through a ring and sighting through a microscope do not always call forth the same choice of eye. The microscope test gives more consistent results than does the test involving sighting through a ring. About two-thirds of the S's tended to sight with the right eye; and one-third, with the left. In the cases in which sighting eye and preferred hand failed to agree as to side, it was rare that anything from the S's reports of difficulties or injuries to eyes or hands could be adduced to explain the disagreement.

17. Difficulty in discriminating between right and left in situations such as driving a car, military or gymnastic drill, and waiting on table, as well as dependence on arbitrary or visual cues in learning to make

the right-left differentiation seem to be associated slightly with lack of coincidence as to side of sighting eye and dominant hand.

18. Reported irregularities or difficulties in speech seem not to be convincingly related to a persisting or a corrected left-handedness, nor to failure of eye and hand preference to agree, but rather to confusion in discriminating right from left.

19. A slight, but probably not reliable, difference was apparent between the S's majoring in the various academic fields. The humanities and commerce majors seemed to be somewhat more strongly right-handed than the science and social science majors.

20. In strength of preference for the right hand the sexes seem about equal.

Our results suggest that hand preference is a trait influenced by many variables among which are probably: instruction, example, convenience, obviousness of choice, previous habits, specific nature and familiarity of the tasks to be performed, hand strength, and genetic factors. The method of measuring strength of preference profoundly influences the results obtained.

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UNE ÉTUDE DE LA NATURE, DE LA MESURE, ET DE LA DÉTERMINATION DE LA PRÉFÉRENCE DE MAIN

(Résumé)

Les choix manuels de 200 étudiants universitaires dans environ 100 situations ont été étudiés au moyen d'observations du comportement et d'un questionnaire. La nature et le groupement des manipulations faits par les étudiants seront suggérés par les noms donnés aux sections du test—Bi-manuel enseigné, Bi-manuel non enseigné, Uni-manuel enseigné, Uni-manuel non enseigné—Opportunité égale, et Uni-manuel non enseigné—Handicap offert.

Les principaux résultats de l'investigation sont les suivants:

1. Les coefficients de constance pour les diverses sections déterminées par la méthode paire-impair varient de $+0,70$ à $+0,94$; tandis que les corrélations entre les résultats faits par 50 étudiants sur deux tests subis à un intervalle approximé d'un mois sont toutes au-dessus de $+0,88$, celle de toute la série étant de $+0,93$. Les corrélations entre les sections varient de $+0,38$ à $+0,88$.

2. Les corrélations partielles indiquent que les sections nommées "enseignées" possèdent quelque chose de semblable non présent dans les autres divisions. Il en est de même des parties du test nommées "non enseignées", "uni-manuelles", et "bi-manuelles." Les manipulations où il s'agit du handicap de position semblent contribuer au test de l'exécution peu ou rien non compris dans les autres divisions.

3. Les résultats de questionnaire donnent de bonnes corrélations avec ceux du test de l'exécution—assez bonnes pour employer ceux-là pour ceux-ci dans le diagnostic général.

4. Les suggestions de bi-modalité dans les distributions des résultats des sections et de ceux de toute la série sont peu. Cependant, la distribution des résultats de droiterie basés sur 20 parties choisies—c'est-à-dire, celles qui ont donné les meilleures corrélations avec les résultats des sections et ceux de toute la série—montre une bi-modalité bien marquée. Environ 6 pour cent de tout le groupe d'étudiants se trouvent dans le mode gauche.

5. La corrélation entre les résultats des préférences de main de 43 paires d'étudiants de même famille est insignifiante comme le sont aussi les r "bi-sérielles" entre les résultats des préférences de main de tous les étudiants et la possession de parents gauchers du degré de père ou mère, de frère ou de sœur, ou de grand-parent.

6. Les suivants ont une relation directe en divers degrés avec la direction et la force de la préférence de main: la direction de la différence de force entre les deux mains; et la préférence à l'égard du côté dans le sommeil, de la mâchoire pour mordre, de l'épaule pour reposer un fusil ou un bâton, de l'oeil pour mirer, de la direction dans laquelle on tourne la tête pour localiser un son très faible, et de la jambe placée dessus quand on met une jambe sur l'autre; tandis que les suivantes n'ont pas de relation: la direction dans laquelle on tend à rouler la langue ou à faire une pirouette, l'efficacité relative des jambes à l'égard du balancement du corps, et l'acuité relative des oreilles.

7. La difficulté à discriminer entre la droite et la gauche semble associée un peu au manque de coïncidence du côté de l'oeil qui mire et de la main dominante. Les irrégularités rapportées et les difficultés de parole ne semblent cependant avoir une vraie relation ni avec une gaucherie corrigée ni avec un manque d'accord entre la dominance de l'oeil et celle de la main, mais plutôt à une confusion dans la discrimination entre la droite et la gauche.

8. Les étudiants qui se spécialisent dans les sciences et les études sociales semblent moins fortement droitiers que ceux qui se spécialisent dans les humanités ou le commerce.

Koch

EINE UNTERSUCHUNG DER BESCHAFFENHEIT, DER MESSUNG, UND DER BESTIMMUNG DER HANDBEVORZUGUNG

(Referat)

Die Handwahlen (manual choices) von 200 Studenten in ungefähr 200 Situationen wurden mit Beobachtungen des Rechnens und mit einem Fragebogen untersucht. Die Beschaffenheit und Gruppierung der Handhabungen, die von den Vpp. ausgeführt wurden, werden durch die den Teilen der Prüfung gegebenen Titel angedeutet: Beidhändige (bimanual) gelernte, Beidhändige ungelernte, Einhändige gelernte, Einhändige ungelernte mit Bietung gleicher Gelegenheit für jede der zwei Hände (equal opportunity), und Einhändige mit Bietung einer Ausgleichung (handicap).

Die wesentlichsten Befunde der Untersuchung sind folgende:

1. Die Zuverlässigkeitskoeffiziente der verschiedenen Teile, mit der Methode der Vergleichung der "gleichen" und "ungleichen" Serien bestimmt (determined by the odd-even method) liegen zwischen +.70 und +.94. Die Korrelationen zwischen den von 50 Vpp. an zwei Prüfungen, die mit Abstand ungefähr eines Monats gegeben wurden, erhaltenen Zahlen liegen anderseits alle über +.88, und die Korrelationszahl der ganzen Serie ist +.93. Die Korrelationen zwischen den verschiedenen Teilen liegen zwischen +.38 und +.88.

2. Teilkorrelationen weisen darauf hin, dass die "gelernt" benannten Teile etwas mit einander gemein haben, was in den anderen Teilen nicht gegenwärtig ist. Das gleiche stimmt für die Teile der Prüfung die "ungelernt," "einhändig," und "beidhändig" benannt worden sind. Die Handhabungen, welche die Lageungleichung (position handicap) in Anspruch nehmen scheinen zu der Tätigkeitsprüfung (performance test) nur Weniges (wenn überhaupt etwas) beizutragen, das nicht in den anderen Teilen mit eingeschlossen ist.

3. Die Befunde aus dem Fragebogen liefern eine hohe Korrelation mit den Korrelationen der Tätigkeitsprüfung—hoch genug, um eine Verwendung des ersteren anstatt der letzteren bei der allgemeinen Diagnose zu ermöglichen.

4. Andeutungen von Bimodalität in den Verteilungen der Teil- und Gesamtserienzahlen sind gering. Die Verteilung der an 20 ausgewählten Bestandteilen ermittelten Rechthändigkeitszahlen (dexterity scores),—die, die mit den Teil- und Gesamtserienzahlen die höchsten Korrelationen liefern,—erweisen aber eine ausgeprägte Bimodalität. Ungefähr 6 Prozent der ganzen Gruppe kommen innerhalb des Umfangs des linken Höhepunktes (left mode) zu liegen.

5. Die Korrelation zwischen den Handbevorzugungszahlen (hand preference scores) von 43 Geschwisterpaaren sind unbedeutend, wie auch die Korrelationen zweiter Serie (bilateral r 's) zwischen den Handbevorzugungszahlen aller Vpp. und dem Bestehen linkshändiger Verwandten auf der Stufe von Eltern, Geschwistern, oder Grosseltern.

6. In verschiedenem Grade zu der Richtung und Stärke der Handbevorzugung in direkter Beziehung stehend sind: Richtung des Starkenunter-

schiedes zwischen den zwei Händen; und Bevorzungen in Bezug auf Wahl einer Seite beim Schlafen, einer [Seite des] Kiefers beim Kauen, der Schulter zum Halten der Flinte oder des Schlagholzes, des Auges bei der Visierung, Richtung des Kopfes bei der Lokalisierung eines sehr schwachen Lautes, und Wahl des oberen zu legenden Beines bei Kreuzung der Beine. Mit der Handbevorzugung unverwandt sind anderseits die Richtung in die man die Zunge zu rullen oder eine Pirouette zu machen, geneigt ist, die relative Wirksamkeit der beiden Beine bei der Balancierung des Körpers, und die relative Scharfsichtigkeit der beiden Ohren.

7. Schwierigkeit bei der Unterscheidung zwischen der rechten und der linken Hand scheint eine geringe Beziehung zu haben zu einem Fehlen an Übereinstimmung zwischen der Seite des visierenden Auges und der Seite der dominanten Hand. Gemeldete Unregelmässigkeiten und Schwierigkeiten in der Sprache scheinen aber nicht überzeugend mit einer korrigierten Linkshändigkeit noch mit einem Fehlen an Übereinstimmung der Seite des dominanten Auges mit der der dominanten Hand in Beziehung zu stehen, sondern eher mit Schwierigkeit bei der Unterscheidung zwischen Rechts und Links.

8. Studenten die als Hauptfach eine Wissenschaft oder eine Sozialwissenschaft wählen scheinen weniger ausgeprägt rechtshändig zu sein als Studenten, die ihr Hauptfach unter den Humaniora oder im Handel ausgesucht haben.

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GENETIC PSYCHOLOGY MONOGRAPHS

Child Behavior, Animal Behavior,
and Comparative Psychology

THE GROWTH AND DECLINE OF
INTELLIGENCE:
A STUDY OF A HOMOGENEOUS GROUP
BETWEEN THE AGES OF TEN
AND SIXTY

From the Institute of Child Welfare, University of California

By

HAROLD ELLIS JONES

AND

HERBERT S. CONRAD

Worcester, Massachusetts
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HAROLD ELLIS JONES
HERBERT S. CONRAD

INSTITUTE OF CHILD WELFARE
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

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I

THE PROBLEM AND THE SAMPLE

A. THE PROBLEM AND THE TEST INSTRUMENT

In 1921 the Army psychologists suggested that "the intelligence of the principal sample of the white draft . . . is about 13 years" (32, p. 785). Probably no other passage in the 890-page report of the Army psychologists aroused greater surprise, indignation, criticism, and controversy. Psychologists (18, 26, 27) at once attempted to fix "the mental age of adults"—some arguing for the conventional 16-year level originally sponsored by Terman, others favoring the 13- or 14-year level suggested by the Army investigations, and still others urging that intelligence continues to develop as far as, if not beyond, the age of 19. A distinction, however, needs to be made between the peak of development, and the "mental age of adults." The latter phrase is as a matter of fact no more justifiable than would be the expression "the mental age of children." In both cases (with possibly rare exceptions) the mental age changes significantly with the progress of the years: among the children there is growth; among the adults decline.

For several reasons, the most satisfactory method of measuring the decline of intelligence among adults requires measurement of the rise of intelligence among comparable groups of children. The younger subjects supply valid regional norms by which to evaluate the decline observed among the adults. The present monograph undertakes principally to study the growth and

decline of intelligence in rural New England, as indicated by 1191 examinations with the Army Alpha intelligence test (Forms 5 and 7).¹ Subsidiary problems also receiving attention are the relation of variability to age, the form of the developmental curve, regional differences, sex differences, and the problem of differential growth and decline according to intelligence level.

A number of reasons prompted the choice of the Alpha, in preference to other standardized tests. The Alpha was carefully prepared, with perhaps more attention to empirical checks, than any other test appropriate for use among adults (32). The Alpha is better adapted for use over a wide range of intelligence than either the Thurstone or the Otis tests--in which the constant shift of tasks tends to create undesirable difficulties of comprehension, especially under conditions of group administration. The fact that the Alpha test had been administered to nearly 2,000,000 men in the Army and had the sanction of the United States Government (32) was sometimes a favorable talking-point in approaching adults who were asked to cooperate in the survey. Finally, the Alpha test has probably enjoyed wider use than any other group test, thus permitting broader comparisons with results obtained by other investigators.

We should be remiss if we did not point out certain defects of the Army Alpha. Outstandingly, we may question whether tests of the nature of general information (such as Alpha Subtests 4 and 8)² should be included in a battery to be used in groups of different ages (1); on the other hand, the growth curves for such tests provide interesting comparisons with the curves from the other Alpha subtests. We could wish that the Alpha contained at least one or two tests in which speed is less at a premium; the factor of speed will be separately considered, in the interpretation of results.

Some readers will consider that our understanding of the term

¹Results from three other tests have been separately reported (12).

²Test 4 ("opposites") is virtually a vocabulary test; Test 8 measures "general information."

"intelligence" requires discussion. Briefly, the aspects of intelligence in which we are chiefly interested consist in the ability to cope with comparatively new problem situations. The problem situations are assumed to be intellectual (involving symbols and relationships), rather than social or emotional; and to be "new" in the sense that previous knowledge or training is of relatively small importance in determining individual differences. We recognize that the diversity of the "previous knowledge or training" of adults makes the measurement of adult intelligence especially hazardous. It may be that the Alpha score of an *individual* adult is only questionably valid as an indication of his intelligence; yet the *average* score of a *group* of adults living in a relatively homogeneous milieu (such as rural New England) may be assumed to possess sufficient validity for serious scientific use. We should *a priori* consider that Tests 1, 3, 5, 6, and 7³ of the Alpha best fulfill the requirements of our definition of "intelligence"; and the performance of groups of persons on this battery of subtests may perhaps be considered the best index (obtainable from Alpha) of the growth and decline of "intelligence."

B. METHOD OF ADMINISTRATION AND DESCRIPTION OF THE SAMPLE

The present report is derived from a community survey conducted in 19 villages of Massachusetts, New Hampshire, and Vermont. In selecting the specific villages as loci for the study, weight was given to the following considerations:

"1. The population examined should be relatively homogeneous in economic status and in educational opportunity. Environmental variables should approach a minimum, to the extent that this may occur under non-experimental conditions.

"2. The population should be entirely native-born of

"These are the oral directions, the "common sense," the disarranged sentences, the numerical completions, and the analogies tests, respectively.

native-born stock, in order to reduce factors of language handicap and of differential group traditions.

"3. The population should be relatively stationary within a limited district, in order that later additional surveys can be made if desired. A stable group has the further advantage that its earlier genealogy and the present family relationships can be more readily traced than in a group comprising many transients.

"The district finally chosen for the survey included a block of nine counties in central and north central New England. These were selected as offering representative rural conditions for the states of Massachusetts, New Hampshire, and Vermont. In the 193 townships (under 2500 population) of these counties, 19 villages were utilized for the purposes of the survey; they were considered, with their adjacent farming areas, to provide a fair sample of the total rural population of the nine counties. The representativeness of these villages appears to be attested by all of the social and economic criteria which have been applied"(13).⁴

To develop community cooperation and insure reasonable completeness of sampling, a carefully elaborated administrative technique was employed. This technique involved the use of a free motion-picture show (3) and supplementary house-to-house (or farm-to-farm) testing. Briefly summarized, our sampling and testing procedures included the following steps:

1. *A study of the community with reference to the general educational level, participation in church and club activities, and the local customs and preferences concerning entertainment.* The communities were suf-

⁴Details as to the representativeness of the towns selected, in such important characteristics as population, racial origin, occupational distribution, literacy, education, and rate of emigration, may be found in Jones (13).

ficiently similar in these respects, so that the experience derived in the first few villages was of value in determining the later policies of the investigation.

2. *Introduction of the project to local groups.* An approach was made to several of the best-known citizens in each community, including usually the minister, and the leading town officials and business men. The first contact was usually made on a social basis, and no more explanation was given than was necessary to elicit their initial interest and approval.

3. *Determination of a meeting place for group testing.* In villages possessing a motion-picture hall (where commercial silent films were shown once a week) arrangements were made with the local exhibitor for rental of the hall and projection service. In the smaller villages the town hall or parish hall was used; in these communities a portable (De Vry) 35-mm. projector gave good service. Where electric lines were not available, the necessary current was obtained from a Westinghouse generator. This was belted to a pulley on an extension of an automobile crankshaft; by means of a field rheostat a satisfactorily constant current of 110 volts could be maintained.

4. *Announcement of the first meeting.* The following modes of advertising were employed: oral announcements in church, at preceding motion-picture exhibitions, and at meetings of the Grange and other local societies; newspaper notices; placards posted in the village and along country roads; free tickets of invitation, circulated by local canvassers. It was not always necessary to employ all of these methods in a

single community; but in each case steps were taken to insure a wide and adequately early announcement the aim being to reach every family in the community, so that a minimum of special selection would occur. The specific inducement to attend was in each instance a free program of motion pictures, consisting of short subjects and a main feature. In choosing the programs to be employed, over fifty reels of films were inspected in previews, and a further selection was made during the early part of the field work on the basis of an objective study of rural preferences (14).

The programs were successful in appealing to rural groups. The attendance consisted not merely of villagers living near the halls, but also of farmers from remote districts. The latter brought their families, and also gave conveyance, in overloaded cars, to neighbors who lacked their own means of transportation. Our small halls were, as a rule, well filled by an amiably curious throng of from 60 to 150 farmers and villagers; in these thrifty New England communities a free show proved a dependable means of gaining popular interest and support.

5. *The group testing.* In the earlier period of the survey, the Alpha test was administered at the end of the main feature of the motion-picture show, and before the final reels of short subjects. While monitors passed out pencils and lapboards and Alpha blanks (Forms 5 and 7 being given to alternate persons in order to prevent copying), the examiner gave a brief talk designed to stimulate the interest of the audience and to motivate them by appeals appropriate to the

specific group. In the later (and principal) portion of the group testing, where somewhat less time was devoted to the development of community rapport, the method was adopted of giving a motion-picture test prior to the Alpha. The motion-picture test took several forms, depending on the particular program used (12); but in each case the test was planned with a view to maintaining the interest and cooperation of the audience and to providing some experience in group measurement. The Alpha was usually administered in the intermission of a second show, scheduled a week or so later.

Generally, then, the Army Alpha was given at the second meeting in a community. The audience had been prepared both for the motion-picture and the Alpha tests through the preliminary advertising, which stated that brief and interesting "questionnaires" would be distributed. Cooperation was usually excellent. A previous report concerning the motion-picture tests has stated that

" . . . under the age of 40, adequate effort was obtained from over 95 per cent. Above the age of 40, a small, increasing number pleaded exemption, usually because of difficulty in reading . . . This excuse, whether bona fide or not, doubtless operated to give a very slightly superior selection of cases in the upper age ranges . . . While an occasional octogenarian filled in our blanks and made a reputable score, it was evident that individuals above 60 or 65, even with corrected vision, were not usually equal to taking a group test, and no systematic attempt was made to collect records beyond the age of 60" (12, p. 228).

The Alpha tests came in smaller type than the (especially printed) motion-picture tests; perhaps for this reason the selection of cases at the upper ages seemed more severe for Alpha than for the motion-picture tests. This selection was compensated for, however, by supplementary home testing.

After the initial period of the survey, the method was adopted of concealing the heading on the Army Alpha by pasting a printed slip across the top of each Alpha blank. This slip contained spaces for the subject to record his sex, age, schooling, and occupation. In place of the intelligence-test caption, a title was given which, together with oral explanations, was designed to motivate an interest in the tests as measures of practical judgment, information, and speed of reading and understanding (2).

6. *Supplementary testing.* One of the primary aims of the general survey was the collection of intelligence-test data on entire families. In a given family, it frequently happened that some members were unable to attend our meetings, due to home duties, conflicting engagements, illness, or lack of interest. Sometimes an entire family would be in attendance, but one member would fail to participate because of the lack of reading glasses, the necessity of caring for a younger child, or (rarely) because of a tendency to non-cooperation.

In conditions even slightly unfavorable, no urging was employed at the time, but the family was marked for a later home visit and test. In many communities an attempt was made to test every family containing

two parents and two or more children, whether or not they had representatives at the group meetings. In other communities a family census was drawn up from the town records, and a random sample was made of two-child families.⁵ In the home or individual tests a technique was used similar to that employed in the group measurements, except that of course the motion-picture entertainment could not be included.

All the records employed in the present study are from native-born individuals coming (with possible rare exceptions) from English-speaking households. About 87% of the total group are primarily of old New England stock, and about 12% of French-Canadian origin, dating back two or more generations in Vermont (13).

The total sample includes 1191 cases. In the Appendix will be found detailed tables presenting statistical descriptions of the total sample, and of various subdivisions. The validity of the present research rests upon the fairness and homogeneity of sampling; we have attempted, in the Appendix, to analyze all relevant features of sampling for which data are available.

SUMMARY

1. The data of the present study consist of Army Alpha intelligence tests of 1191 subjects between the ages of 10 and 60.

⁵Due to the absence of a differential birth-rate in our rural New England communities (5), this selection has not introduced any bias of sampling.

2. The sample is derived from 19 villages in rural Massachusetts, Vermont, and New Hampshire; these villages are considered, with their adjacent farming areas, to provide a fair sample of the rural population of the three states.

3. The testing procedure included the use of group tests in community halls, free exhibits of motion pictures being offered as an inducement for attendance. The sampling was completed by supplementary house-to-house testing.

4. The present study attempts primarily to trace the growth and decline of mental-test ability between the ages of 10 and 60. Subsidiary problems also receiving attention are the relation of variability to age, the form of the developmental curve, regional differences, sex differences, and the problem of differential growth and decline according to intelligence level.

II

THE GROWTH AND DECLINE OF INTELLIGENCE

Table 1 gives the distribution of scores of each age group in the total Alpha test. The growth and decline of Alpha scores is shown graphically in Figure 1, which presents a smoothed curve based on the average of the mean and median performance of each age group.⁶ The curve has been drawn in terms of T-scores (21),⁷ with the raw score equivalents listed on the right-hand side of the graph.

The chief characteristics of the curve may be summarized as involving a linear growth to about 16 years, with a negative acceleration beyond 16 to a peak between the ages of 18 and 21. A decline follows, which is much more gradual than the curve of growth, but which by the age of 55 involves a recession to the 14-year level. It may be noted that the form of the adolescent growth curve agrees closely with that reported by Lufkin for the Army Alpha in rural schools (20), and also with Teagarden's curve for the juvenile population of Mooseheart (26). To the age of 15 there is also close agreement in actual scores, but between 16 and 20 the Lufkin and Teagarden medians

⁶For a discussion of the method employed in curve-fitting, see Appendix B. It may be noted that the numbers of cases in the various age groups are unequal (Table 6, p. 277); the result is a fit which on first impression looks less accurate than if the curve had been fitted without regard to the number of cases. Each curve-fit has been tested to insure that the sum of the deviations, weighted for n , equals approximately zero (see footnote no. 17).

⁷See Appendix B.

TABLE 1
CORRELATION BETWEEN CHRONOLOGICAL AGE AND ARMY ALPHA
TEST SCORES*

Age → Score ↓	10	11	12	13	14	15	16	17	18	19- 21	22- 24	25- 27	30- 34	35- 39	40- 44	45- 49	50- 54	55- 59	Total
200-	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	2
190-	...	...	...	...	...	...	...	1	...	...	1	1	1	...	...	...	...	...	4
180-	...	...	...	...	...	...	...	1	2	...	...	...	...	1	...	...	...	...	4
170-	...	...	...	...	...	...	...	2	6	...	2	3	3	4	...	1	1	...	22
160-	...	...	...	...	...	1	1	...	2	2	1	2	2	...	3	2	2	...	18
150-	...	...	...	...	...	...	5	4	2	4	3	4	2	1	4	1	2	2	34
140-	...	...	...	...	...	2	4	3	1	5	...	4	5	4	6	5	1	1	41
130-	...	...	...	...	2	4	6	1	3	1	3	1	9	7	7	3	2	1	50
120-	...	...	...	1	1	3	6	6	1	6	4	1	7	8	5	1	7	...	57
110-	...	...	2	2	4	2	8	5	6	6	4	8	7	6	6	5	3	1	75
100-	...	2	1	4	4	6	3	2	1	3	3	6	5	5	5	3	3	2	58
90-	3	...	2	3	5	9	5	4	5	9	3	12	2	7	9	4	3	2	87
80-	...	2	8	7	13	8	10	7	3	5	2	10	11	11	10	7	2	5	121
70-	1	2	7	9	1	8	5	3	3	10	6	12	12	5	5	5	4	2	100
60-	5	11	5	6	9	6	5	4	8	7	3	6	8	5	7	8	5	5	113
50-	2	11	10	14	7	3	5	4	1	11	2	9	8	9	8	11	6	2	123
40-	8	3	9	9	4	3	4	2	5	1	4	3	7	6	5	3	6	2	84
30-	4	8	16	5	3	3	4	4	1	6	3	3	6	8	3	4	7	6	94
20-	7	11	4	6	2	2	3	...	1	1	1	1	5	7	3	2	3	...	59
10-	2	1	1	5	...	1	...	...	...	...	1	2	5	3	6	4	2	...	33
0-9	2	4	...	...	1	...	1	...	...	...	...	1	1	...	1	...	...	1	12
Total	34	55	65	71	56	61	75	50	46	87	44	88	106	96	97	68	59	33	1191

*The class interval containing the mean score for each age group has been heavily boxed.

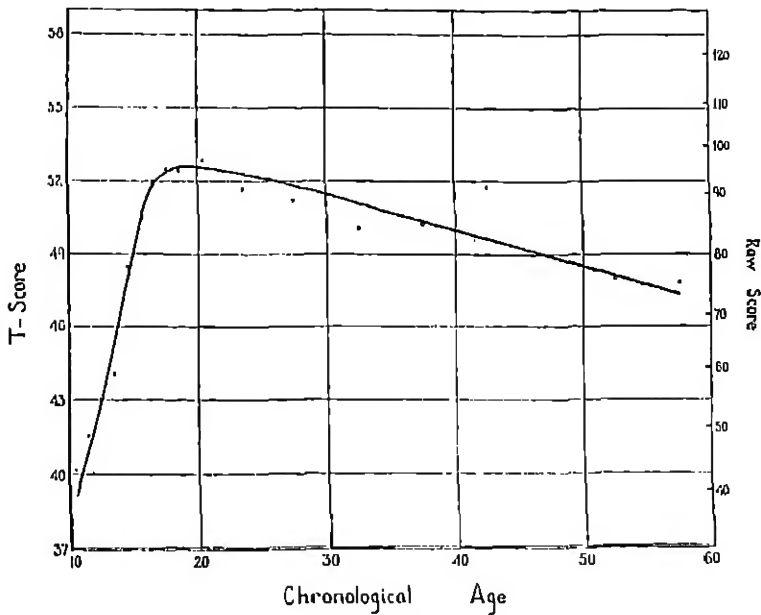


FIGURE 1

SMOOTHED CURVE OF GROWTH AND DECLINE OF ARMY ALPHA
 TEST SCORES OF TOTAL RURAL NEW ENGLAND SAMPLE
 Original data (average of mean and median) in small circles

run slightly higher, probably due to some degree of selection at these upper ages. It should be observed that the method of community sampling employed in the present study was designed to avoid those selective effects which must inevitably occur in a survey such as Lufkin's, limited to the public schools. The decline of intelligence scores beyond early maturity is similar to results previously reported for a variety of motor, sensory, perceptual, and learning functions (7; 24; 29, pp. 106, 133-136).

Perhaps the chief interest in the present material

lies in the possibility of comparing the growth curve with the curve of decline, for a population regarded as homogeneous. Considerable attention should, therefore, be given to the validity of our sampling at various age levels. We should analyze the data with these questions in view: To what extent is the decline in intelligence affected by sampling changes at successive ages? Can it be shown that the decline is due to a progressively poorer sampling, rather than to a bona-fide decrement in human abilities? Later sections will consider other problems bearing on the significance of the developmental curves; these problems include a study of sex differences; a study of the Alpha subtests, with a consideration of the validity of total Alpha score as a measure of intelligence; and a comparison of growth and decline in different intelligence groups.

Three methods are possible for testing the homogeneity of sampling:

1. A comparison of cases tested in halls with those obtained as a result of home canvassing.
2. A comparison of groups of communities in terms of completeness of sampling.
3. A comparison of adolescents and adults from the same family groups, with samples of less homogeneous origin.

The statistical constants forming the basis for the three comparisons suggested above may be found in Table 7 of the Appendix. Figure 4 presents curves for the 911 individuals tested in community groups, and for the 280 individuals tested in homes. The hall sample tends to be drawn more largely from village

residents and from agricultural families living near villages. Observation of the actual sampling procedure has convinced the writers that the incentives employed in bringing subjects together in groups were (to a slight degree) progressively less effective for individuals of lower intelligence in the upper ages. In other words, while a fairly representative sample was obtained in adolescence and early maturity, in later maturity the group-tested sample tended to be drawn more largely from homes of superior social and educational status. The effect of this is to maintain the curve of decline more nearly on a plateau; in the home-tested cases, on the other hand, a very accelerated decline is to be observed, because one of the functions of the home tests was to add cases which had been missed in the halls, and thus to correct the incompleteness of the hall sampling. The curve for the total sample falls between the curves for the group-tested and the home-tested cases, and doubtless presents a truer picture than either of these.

However, in view of the preponderance of hall-tested cases, it may be suspected that the curve for the total sample in Figure 1 is held up to a somewhat slower decline than would be the case if selective factors were balanced by a more comprehensive home testing. This possibility can be investigated by comparing communities which were very intensively tested with those in which the sampling (for reasons of time) was less thorough. In these terms, three divisions of the total sample may be recognized: 14 communities which were "extensively sampled" (Group A), 5 com-

munities which were "intensively sampled" (Group B), and a subgroup of the latter consisting of 3 communities which were "most intensively sampled" (Group B₁). In Leverett Village and East Leverett, approximately 90% of the entire population between the ages of 10 and 60 were tested. Illness, absence from town, and a very few cases of non-cooperation, accounted for the cases not tested. In Gaysville an equally comprehensive program was not attempted, but in addition to the hall tests records were obtained by a home canvass from every family containing two or more children. The five communities of Group B include a fair range of the characteristics of the total sample: Gaysville is primarily an agricultural community, sparsely settled over a wide area; Dana is a small compact rural village, also chiefly agricultural; Leverett and East Leverett are small villages with both industrial (a box factory) and agricultural interests; the remaining town, Bethel, is one of the largest in our sample and contains a large proportion of non-agricultural workers. Each of these communities, moreover, is matched by one or more communities in the remaining group of towns (Group A), having a similar size, location, and occupational distribution. The curves for these three subsamples, given in Figure 3, indicate that the less complete or more questionable the subsample, the less rapid the decline of Alpha scores beyond the peak. It seems likely, therefore, that the curve in Figure 1 for the total sample must be accepted

as a conservative or *minimum* estimate of the decline of adult intelligence beyond the age of, say, 20.⁸

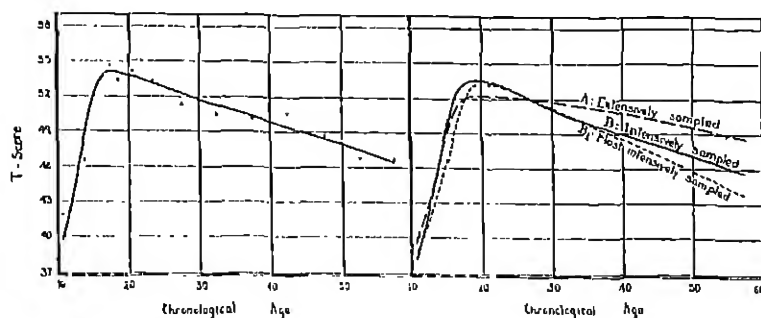


FIGURE 2
GROWTH AND DECLINE OF ABILITY
IN THE ABBREVIATED ARMY ALPHA
TEST (TESTS 4 AND 8 OMITTED) FOR
TOTAL RURAL NEW ENGLAND
SAMPLE

FIGURE 3
GROWTH AND DECLINE OF ABILITY
IN THE ARMY ALPHA TEST FOR
GROUP A (EXTENSIVE SAMPLING),
GROUP B (INTENSIVE SAMPLING),
AND GROUP B₁ (MOST INTENSIVE
SAMPLING)

Further evidence in support of this view may be obtained from Figure 5, which gives curves for three types of cases: (1) In the "complete-family group" both parents of a family and one or more children of these parents were tested by the Alpha; the only children omitted were those too young to be tested by the Alpha, and an insignificantly small number who were out of town. (2) In the "partial-family group" are included either two or more siblings of a family, or

⁸Differential mortality is an additional possible factor in this connection. It seems reasonable to suppose that within a given rural population, as within an urban, intelligence is more or less correlated with the occupational and hygienic conditions which make for longer life. Hence, age curves for intelligence, unless derived by cumulative testing of the same individuals, will at the upper ages decline too slowly, because of survivorship selection.

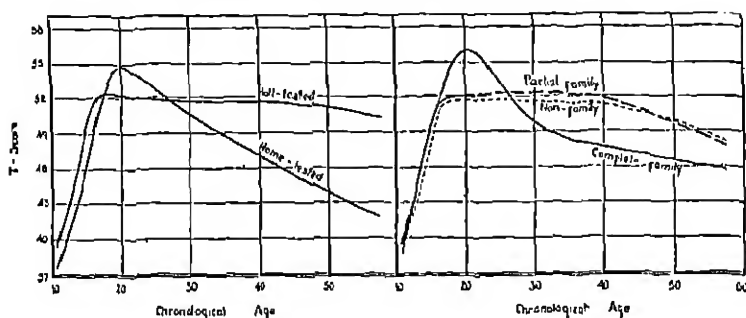


FIGURE 4
GROWTH AND DECLINE OF ABILITY
IN THE ARMY ALPHA TEST FOR
ALL-TESTED AND HOME-TESTED
CASES

FIGURE 5
GROWTH AND DECLINE OF ABILITY
IN THE ARMY ALPHA TEST FOR
THREE GROUPS: "COMPLETE-FAM-
ILY," "PARTIAL-FAMILY," AND
"NON-FAMILY"
(See text.)

one parent and his or her child or children. (3) In the "non-family" group are included all those cases not already classified in the two preceding groups, viz., single siblings, one or more adults in a family with no child tested, or unmarried persons without a sibling or parent tested.

Figure 5 shows that the curve for the complete-family group, like that for the home-tested group, drops more rapidly and to lower values than the curve for the total sample. Homogeneity of sampling in the complete-family group seems indubitable, since the falling portion of the curve is based on measurements of the parents of children in the rising part.⁹ It is

⁹If dull parents bear a larger number of offspring than bright, or bear the same number of children within a shorter time, then the rising limb of our intelligence curves is, in a sense, unduly weighted with dullness. Keeping in mind the virtual absence of a differential birth-rate in the communities investigated (5), and, moreover, the

interesting and important to note that selective migration of brighter adults into the cities can have had little or no effect upon the curve for the complete-family group.¹⁰ Within the limits of the number of cases involved, then, the accelerated drop in the complete-family curve appears thoroughly authentic. It may be noted that only about half of the complete-family group were home-tested (Table 14, pages 284-285).

We may conclude that for reasons of sampling Figure 1 must be interpreted as offering a conservative

imperfect correlation between parental and filial intelligence (13), we may doubt if either of these factors operates significantly.—It is probable that the rising portion of the curve is weighted with first-born rather than last-born children (in view of the fact that many families, at the time of testing, were not yet completed). But it has been shown that, at least for these communities, and probably quite generally, there is no relation between birth order of offspring and intelligence (11, 15).—It is on *a priori* grounds extremely doubtful if a differential death-rate is the cause of the drop in intelligence-test score during maturity; indeed, a differential death-rate, if present, would more likely operate to prevent a decline (footnote 8).—Finally, it might be suggested that in the curve for the complete-family group the rising and the falling limbs of the curve are not comparable, due to the regression of offspring to the mean of the race. This suggestion, if it is valid, assumes that the intelligence of rural New England is significantly inferior (or superior) to that of the mean of the race—an assumption which we are by no means prepared to admit. Moreover, significant regression is probably not to the mean of the race, but to the mean of comparatively recent ancestry. For our rural New England group, it may be questioned if the mean of recent ancestry differs sufficiently from the mean of the present generation of parents to make the regression of offspring a factor of importance in the present study.

¹⁰If the decline in intelligence within our sample of adults were due simply to the continuous emigration of brighter parents, we should expect the children of older parents to be progressively inferior in brightness to the children of younger parents. A comparison of Table 2 with Table 3 fails to indicate any such inferiority. Selec-

picture of the age decline in intelligence-test scores.

But there are other reasons which point in the same direction. In the first place, correction for zero scores would lower the curve at both of its extremes. These zero scores are not uniformly distributed through the various age groups, being more heavily concentrated at the lower and upper ends of the age range (Table 15, page 287). Inasmuch as a zero score probably denotes a less-than-zero ability (in terms of equal units), correction for this factor would to some extent decrease the measures of central tendency, especially for the younger and older members of our sample. Correction for zero scores, in other words, would to a slight degree emphasize both the rise and the decline in the intelligence curves.

tive migration, then, is not the cause of the drop in the intelligence curve for the complete-family group; it is even less likely the cause of the (slower) decline in the total sample.

TABLE 2
INTELLIGENCE OF CHILDREN OF PARENTS IN THE "COMPLETE-FAMILY" GROUP

CA of parent	No. of children*	CA of children		Alpha scores of children	
		Mean	Median	Mean	Median
25-29	5	12.9	11.8	51.0	52.5
30-34	31	12.7	12.5	56.9	60.7
35-39	74	14.4	13.9	66.0	56.4
40-44	77	15.6	15.2	78.9	79.4
45-49	68	17.2	16.9	86.5	80.0
50-54	77	17.6	17.1	104.9	101.3
55-59	12	26.4	27.0	105.0	105.0

*Each child is recorded twice, once for each of its parents (except in the rare instances where one of the parents, being aged 60 or over, has been excluded from our sample). As the regression may indicate, the correlation between children's and parents' CA is not high, being .44 for the completed-family group (and .50 for the partial-family group, not shown in the table above). The correlation is markedly heteroscedastic; i.e., the age range of children of older parents is much greater than the age range of children of younger parents.

Of more fundamental importance in interpreting the significance of Alpha scores, however, is the fact that a proper allowance for the advantage of age and experience in two of the Alpha subtests (Tests 4 and 8) would lower the curve for adults (and raise the curve for the younger ages). Tests of native intelligence assume that the subjects have all enjoyed equal familiarity with the experience variables affecting test score. In the case of information tests (such as Tests 4 and 8¹¹) administered over a wide age range, this assumption is manifestly and provedly invalid (1). Particular attention is called, therefore, to Figure 2, which presents the curve of growth and decline of the modified Army Alpha test (Tests 4 and 8 deleted). It is suggested that this curve is more acceptable than the curve of Figure 1 as a picture of the development of native intelligence with age. In this, the recession by age 55 has reached nearly the 13-year level, as compared with the 14-year level reached at age 55 in Figure 1.

Upon examination of the developmental curves for the individual subtests (Figure 6, and Table 3), one is impressed by the great variation. In some tests, the adolescents are superior to most of the adults; in other tests, the adults, on the average, surpass the adolescents. In some tests, the peak of development is reached around 18 years; in others, a slight rise continues well into advanced maturity. In some tests, decline is fairly precipitous; in others, decline is negligible. This varia-

¹¹Test 4 ("opposites") is virtually a vocabulary test; Test 8 measures "general information."

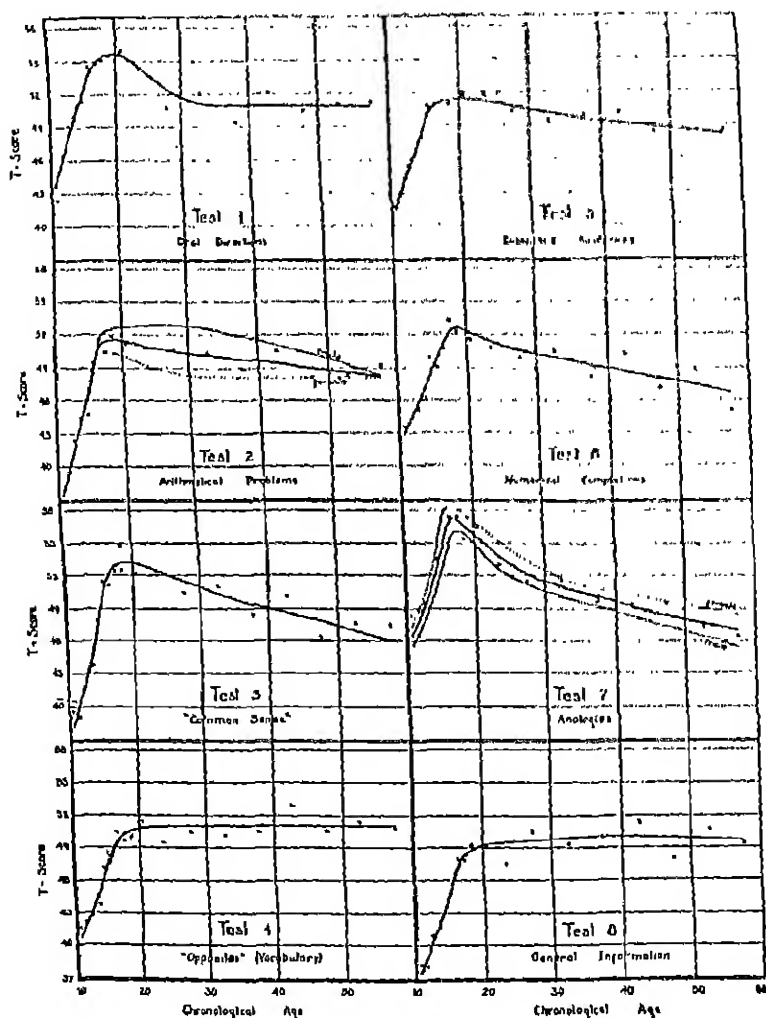


FIGURE 6
GROWTH AND DECLINE OF ABILITY IN THE INDIVIDUAL SUBTESTS
OF THE ARMY ALPHA

Males —————; females - - - - -; total ————

The T-score values for each test are given at the left; chronological age is given at the bottom; original data for total group are plotted as small circles.

TABLE 3
STATISTICAL CONSTANTS (MEAN, MEDIAN, AND S.D. OF RAW SCORES) OF TOTAL SAMPLE

Age group	Total Alpha		Abbreviated Alpha*		1		Alpha Subtest No. 2		3	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
10	44.4	42.5	33.1	32.1	3.7	3.8	5.0	4.6	4.2	4.0
11	46.8	50.5	33.5	32.9	4.7	4.9	5.4	5.4	5.9	4.0
12	56.7	52.5	40.2	40.3	5.2	5.8	6.4	6.6	5.2	5.1
13	60.5	57.5	43.6	42.5	5.5	6.0	6.8	7.4	5.9	5.9
14	75.7	80.8	53.1	54.0	5.8	6.5	7.1	7.4	7.5	7.2
15	85.7	85.6	60.3	59.4	6.9	7.4	8.8	8.8	8.7	8.5
16	93.5	91.0	63.4	63.8	6.8	7.5	9.4	9.6	8.4	8.5
17	96.6	92.5	66.0	67.1	7.1	7.5	9.1	9.1	9.2	8.7
18	97.0	92.0	63.6	59.2	7.2	7.6	9.6	9.5	9.7	9.8
19-21	100.7	92.8	65.1	63.5	7.2	7.8	9.7	9.0	9.1	8.6
22-24	91.8	90.0	61.0	60.8	6.8	7.3	9.6	8.9	8.9	9.0
25-29	90.5	87.0	55.8	52.0	5.9	6.1	9.4	8.9	8.4	8.1
30-34	87.0	80.9	54.9	49.4	6.0	6.8	9.1	9.0	8.5	8.3
35-39	85.1	84.0	52.2	50.5	5.5	5.8	8.6	8.6	7.4	7.7
40-44	92.2	90.6	54.2	50.4	6.2	6.7	9.1	9.2	8.2	8.0
45-49	80.7	74.0	49.0	46.3	5.7	6.3	8.6	8.2	6.8	6.8
50-54	81.3	71.5	47.2	40.6	5.9	6.3	8.5	8.4	7.3	7.3
55-59	78.6	72.5	45.5	41.3	6.0	6.3	9.0	8.5	7.2	7.1

TABLE 3 (continued)

Age group	4		5		6		7		8	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
10	5.1	4.4	6.2	5.7	4.9	2.9	9.7	9.6	8.1	5.5
11	5.4	5.3	6.6	4.2	5.2	3.3	8.5	7.7	8.3	6.1
12	6.5	5.5	8.4	9.1	5.9	3.0	11.0	10.5	10.9	10.4
13	7.5	6.9	9.4	4.7	6.5	3.4	12.2	11.3	11.7	11.0
14	10.3	11.0	10.1	10.9	7.7	3.2	16.1	14.2	14.2	12.9
15	11.6	11.4	12.5	5.0	7.1	3.9	18.3	18.2	16.5	8.0
16	13.4	14.2	12.6	6.1	8.1	4.0	20.4	22.5	18.8	9.0
17	13.4	12.8	12.7	5.2	9.0	4.1	21.0	21.5	18.9	9.5
18	14.3	12.5	12.4	6.1	8.5	4.2	19.5	17.5	19.7	9.5
19-21	16.2	13.7	13.5	6.7	8.3	4.6	19.5	19.7	20.3	9.5
22-24	13.5	12.3	12.8	5.9	8.5	4.4	16.4	13.0	18.0	9.7
25-29	14.1	13.6	12.1	5.7	7.6	4.0	14.1	11.7	20.8	9.1
30-34	14.0	13.0	11.3	6.5	7.7	3.9	14.2	11.6	20.1	10.1
35-39	14.5	13.8	11.6	6.8	6.9	4.1	12.1	10.1	20.0	9.8
40-44	16.6	16.2	11.8	7.0	7.7	4.1	12.6	8.9	21.4	9.8
45-49	13.7	14.3	10.5	5.9	6.6	4.0	11.5	9.8	18.5	9.9
50-54	14.5	15.0	10.9	7.0	6.9	4.4	10.8	6.8	21.0	9.4
55-59	13.9	14.5	10.9	6.1	6.0	4.6	8.6	7.6	20.0	9.7

*Total Alpha minus Subtests 4 and 8.

tion can hardly be completely explained on the basis of present knowledge. Certainly no simple "verbal factor" can explain the results. A previous study of the individual items of the Stanford-Binet, administered in the same communities as the Alpha, led to the emphasis of the differential influence of rather specific environmental factors (17); our interpretation of the sustained rise in Tests 4 and 8 (given on pages 249-252) may be considered in accord with this environmental hypothesis. There is no evidence in Figure 6 to support Thorndike's suggestion (29, p. 158) that the linguistic and arithmetical items impose a special handicap upon adults long out of school. Of special interest is the observation that the tests showing the most rapid decline are Tests 7 (analogies), 3 ("common sense"), and 6 (numerical completions). These tests may perhaps be considered, at least on *a priori* grounds, to be the best in the Alpha for the measurement of basic intelligence, i.e., to be the most free from the influence of environmental variables, and from the accumulative effects of differential experience. Our results here confirm Thorndike's conclusion that age exerts its most adverse influence upon native capacity or "sheer modifiability" (29, p. 106).

The utility of the distinction between basic intelligence and acquired abilities is emphasized by the changes, with age, in the proportional contribution of each subtest to total Alpha score (Figure 7).¹² Be-

¹²The percentage contribution of a given test at a given age is obtained by dividing the raw score equivalent of the smoothed T-score for the test at the given age, by the sum of the raw score equivalents of the smoothed T-scores of all the subtests at the given age. It is to be observed that we are analyzing central tendency, and not variance; the customary techniques for the analysis of variance (9) have therefore been deliberately disregarded.

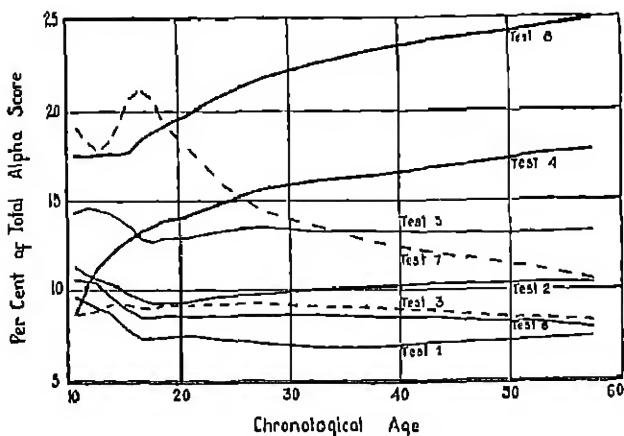


FIGURE 7

PROPORTIONAL CONTRIBUTION OF EACH ALPHA SUBTEST TO
TOTAL ALPHA SCORE AT EACH AGE

tween the ages of 50 and 60, about 40% of total Alpha score is derived from two tests—Tests 4 and 8; at age 10, these tests contribute only 25%. As represented in mental tests, then, the effective intellectual power of the adult, much more than that of the 10-year-old, is evidently derived from accumulated stocks of information. One may ponder as to what can be done to give the elderly adult the advantage, not only of experience and training, but also of undiminished native talent. Here is a problem which may well occupy the best energies of future investigators in the field of human biology.

A number of additional factors deserve to be considered as having a possible influence upon the developmental curves.

1. It is possible that older persons are less readily motivated, that they adopt a conservative policy with reference to their resources, refusing to expend their energy unless it is necessary, or obviously and importantly useful to do so. With reference to this hypothesis it would be possible to cite evidence from our field observations which suggest that age was of little importance in determining incentive. It must be remembered that the whole present research was planned precisely with respect to the problem of rapport and cooperation, and that records were made of all cases showing resistance or apparent weak interest. Among those who took the tests, older subjects appeared, on the average, to be as earnest as younger ones in working for a good score. Evidence of greater weight, however, may be found in the curve of decline for the home-tested cases (Figure 4). It was among these cases that conditions affecting motivation were undoubtedly best controlled and best adapted to the individual. An examination of the means, standard deviations, and percentage of zero scores among home-tested as compared with the hall-tested cases (Appendix, Tables 7 and 15) yields nothing to show that the age decline in intelligence-test score is a function of differential motivation.

2. Older persons may be handicapped by failing eyesight. If this were an important factor, we should expect to find a more rapid decline in the hall-tested than in the home-tested cases, for with the latter it was possible to obtain lighting conditions best adapted to individual needs. We should expect to find little or no decline in Test 1, which is given with oral directions and involves a minimum of reading. And we should expect to find that tests requiring similar tasks with respect to reading (such as Tests 7 and 8, or Tests 3 and 4) would exhibit similar curves of decline. None of these expectations has been met. From this, it is not contended that visual abilities (even when corrected with glasses) remain unaffected by age; but merely that (within the age range of our sample) we find no evidence of any significant effect of eyesight upon average Alpha score.

3. Older persons may be handicapped by an increased difficulty in hearing oral instructions. If this were an important factor, we should expect the decline with age to be especially rapid in Test 1 (which involves oral instructions);¹⁹ and we also should expect the

¹⁹In interpreting the curve for Test 1 (Figure 6) it is well to observe that the proportion of adults tested at home remains fairly constant from age to age—being 30% between the ages of 22 and 39; and 32% between the ages of 40 and 59 (see Table 6, page 277).

home-tested adults to show some advantage from a procedure in which extreme care was taken to note and adapt to possible sensory difficulties. The same considerations apply here as in the preceding section, and our conclusion is again negative with reference to the importance of increasing sensory handicap, in determining the results of the present study.

4. Adults may be handicapped by the remoteness of the period of formal schooling. Probably the subtest most closely related to schooling is Test 2 (arithmetic). In this test the rate of decline, far from being rapid, is, as a matter of fact, relatively slow. Willoughby (31) has obtained a similar result with an arithmetic test. It may be noted that improvement in the various subtests persists for a period of four or five years after 15 or 16, when most of our subjects complete their schooling. Within the age range of the present sample, then, remoteness of schooling fails to explain the decline of intelligence-test score with age.

5. Adults may be handicapped by disuse of the functions tested in the various subtests of the Alpha. The maintenance of high test scores by adults in Tests 4 and 8 (vocabulary and information) lends some possible support to this theory. But we must not forget the proper distinction between tests of basic intelligence or capacity, and tests of information or ability (1). Intelligence tests include the latter only in the attempt to measure the former; and we have already pointed out the limitations of information tests for the measurement of intelligence over a wide age range (pages 249-253). Opposed to the theory of disuse is the fact of decline in Subtest 1 (directions) and Subtest 3 (common sense) of the Alpha; and Price's finding of a regular decline with age in tests of perceptual ability (23).

6. It has been suggested that adults work less rapidly than adolescents, and that this penalizes the adults because the Alpha is primarily a "speed," rather than a "power" test. Requirements of speed may handicap the older adults in various ways, from the mere mechanics of managing a pencil to habits of rapid reading, or to attitudes favoring rapid performance. This problem arose in an earlier study of the growth curve of performance for a series of tests of learning and recall [Motion-Picture Tests A, B, and C (12)]. In these tests, the factor of speed was analyzed by comparing scores for the earlier part of each test, which every one had time to complete when working at his own rate, with scores for the

total test worked within a time limit. The elimination of the speed factor did not alter the form of the developmental curve. This result is of peculiar significance when it is remembered that the Alpha and the motion-picture tests show a fairly high correlation with each other and yield much the same type of developmental curve (3). The cause of this general correspondence between the curtailed motion-picture tests (administered without time restrictions) and the Alpha (administered with strict time limits) seems to lie in the fact that Alpha is not essentially a "speed" test, and the fact that adults do not, as sometimes supposed, work more accurately than adolescents. We cannot here assemble the evidence which indicates that Alpha measures "power" as well as "speed"; it will be sufficient to point out that in samples of adults as well as children (32, pp. 333, 634), the Army Alpha correlates fairly highly with the Stanford-Binet; and this latter can hardly be termed a test merely of "speed."

If the inferiority of the older individuals, which is especially apparent in Test 7, is due chiefly to factors producing retardation in speed, the old would be expected to drop faster in "items attempted" than in "items correct."¹⁴ The diminution in scores would then be due, not to a loss of mental "power," but merely to a slower rate of work. A significant comparison can be made between items attempted on Tests 7 and 8. These maintain practically the same level (there are a total of 40 items in each test) up to the age of 20. Beyond this age, the "attempts" show a decline in Test 7 but not in Test 8—indicating that the cause of the decline lies in the intellectual difficulty of the task and not in factors associated with speed of reading or in the motivation of rapid work. In Test 8, the ratio of "items correct" to "items attempted" increases slightly but consistently after adolescence; this result—quite contrary to that found for Test 7—is evidently due to the accumulation of relevant definite information rather than to an improvement in auto-criticism or in habits of intellectual work. Our results appear to support Thorndike's conclusion that "the older manifest little more caution and care in intellectual operations than the young adults or adolescents" (29, p. 174).

7. Allied to the fallacious "speed-accuracy" theory, is the suggestion that adults make low scores principally through their failure

¹⁴We are indebted to Dr. Daniel Harris for statistical work in the investigation of this problem.

to comprehend directions promptly. If this were an important factor, we should expect to find an excessively rapid decline in Test 1, which depends on oral instructions, and Test 6, which has unusual and complicated instructions. We should expect to find that tests with instructions of similar difficulty, such as Tests 4 and 5, would exhibit similar curves of decline. We should expect that when two tests show dissimilar decline (as in Tests 3 and 5) the more rapid decrement would be associated with more difficult instructions. Such expectations are not, however, borne out by the facts. Probably one reason making this factor of minimal importance, is that particular care was always taken, through every legitimate means, to secure the best possible attention and comprehension of the directions to every subtest. While the subjects read the directions, they were at the same time spoken by the Examiner loudly, clearly, and rather slowly, with deliberate and well-practiced pauses and inflections. The administrative conditions were good; they were, in fact, best for that group showing the most rapid decline (Figure 4). We are almost tempted to suggest that the comparatively small number of individuals who may have been penalized by their failure to understand the directions promptly deserved to be so penalized.

It must be recognized that some of the considerations listed in the last few pages furnish better material for further research than for final conclusions. Even with a conservative attitude on these points, however, it seems difficult to escape the conclusion that the basic intelligence of the older generation is, on the average, poorer than that of the younger. Whatever the advantage of age may be, it does not seem to lie in inherent, basic capacity.

With reference to individual cases, it is of course ill-advised to make any sweeping application of our average results. As Thorndike has remarked in his discussion of the data of the present monograph, within the age range of the present sample of adults, "individual differences amongst those of the same age . . .

enormously outweigh differences between ages . . .” (29, p. 159). It is also probably true that some individuals, through good fortune of endowment or circumstance or care, are able for many years to forestall the decline which ordinarily takes place with the passage of years. We must recognize that the high standard deviations of Table 3 indicate that individual differences are the rule and not the exception. Without attempting, then, to minimize the importance of considering each person by himself, we may still speculate whether the developmental curves in Figures 1-7 do not point to important social problems. In the management of educational, industrial, and political affairs, the accumulation of power in the hands of seniors may be assumed to be socially desirable only (1) if later maturity brings with it an accumulation of information or social skills or other favorable factors which compensate for a declining mental power as measured by our tests; or (2) if the decline in mental power is greatly delayed in the case of the very superior.

SUMMARY

1. On the basis of 1191 examinations of unselected rural New England subjects, developmental curves are presented of the growth and decline of ability in the Army Alpha intelligence test. The chief characteristics of the developmental curve for the total Alpha test may be summarized as involving a linear growth to about 16 years, with a negative acceleration beyond 16, to a peak between the ages of 18 and 21. A decline

follows, which is much more gradual than the curve of growth, but which by the age of 55 involves a recession to the 14-year level. The developmental curves for the individual subtests of the Alpha display important differences among themselves. In some tests, the adolescents are superior to most of the adults; in others, the adults, on the average, surpass the adolescents. In some tests, the peak of development is reached around 18 years; in others, a slight rise continues well into advanced maturity. In some tests, the decline beyond the maximum is fairly precipitous; in others, it is practically negligible. This variation in the developmental curves of the individual subtests can hardly be completely explained on the basis of present knowledge. Certainly no simple "verbal factor" nor schooling factor can explain the results. It is noteworthy that the tests of information (Test 4, opposites or vocabulary, and Test 8, general information) fail to exhibit a post-adolescent decline. Decline is most rapid in Subtests 7 (analogies), 3 ("common sense"), and 6 (numerical completions). These tests may perhaps be considered, at least on *a priori* grounds, to be the best in the Alpha for the measurement of basic intelligence or intellectual capacity.

2. The decline of ability beyond the age of 21 is not due to errors of sampling. In fact, the post-adolescent decline is especially marked in the developmental curve for the group of towns most intensively sampled; and also in the curve for the "complete-family" group, in which homogeneity of sampling from age to age seems specifically assured.

3. The decline of adult ability beyond the age of 21 is not due to faulty administration of the Alpha. Examinations administered in the homes of the subjects, under conditions closely approximating those of individual testing, lead to the same conclusion as in the case of group tests.

4. The decline of ability in the total Alpha test, and the peculiarities of the developmental curves for the individual subtests, cannot be successfully explained by failure of motivation, remoteness of schooling, lack of understanding of directions, disproportion in attention to accuracy versus speed, lack of practice in the test functions, failing hearing, or failing eyesight.

5. From the point of view of measuring basic or native intelligence, the information tests of the Alpha (Tests 4 and 8) present an unfair advantage to those in the upper age brackets. Exclusion of Subtests 4 and 8 from the Alpha gives a picture of comparatively more rapid growth among the adolescents and more rapid decline among the adults.

6. In the sixth decade of life, about 40% of total Alpha score is derived from two tests (Test 4 and Test 8); at age 10, these tests contribute only 25%. As represented in mental tests, then, the effective intellectual power of the adult, much more than that of the 10-year-old, is evidently derived from accumulated stocks of information.

7. Any sweeping application of our average results to individual adults would be ill-advised. Within the age range of the adults in the present sample, individual

differences among those of the same age outweigh differences between the ages.

8. The curves for the growth and decline of mental-test abilities are regarded as pointing to important social problems.

III

REGIONAL AND SEX DIFFERENCES

A. REGIONAL DIFFERENCES

In studies of the intelligence of school children, it has frequently been reported that test scores average lower in rural districts than in urban communities. This difference arises partly, though not wholly, through the environmental handicap of the rural children. A previous report by the writers, comparing urban and rural subjects, has indicated some of the differentiating factors which are operative in the individ-

TABLE 4
RAW ALPHA SCORES OF RESIDENCE GROUPS*

Age group	Total Alpha Residence		Test 7 Residence		Test 8 Residence	
	Village	Remote	Village	Remote	Village	Remote
	<i>Mean</i>	<i>Mean</i>	<i>Mean</i>	<i>Mean</i>	<i>Mean</i>	<i>Mean</i>
10	48.1	18.3	10.1	1.3	9.1	3.3
11	45.4	52.5	10.2	11.0	8.0	11.0
12	60.7	46.7	13.1	10.0	12.2	8.0
13	59.8	55.0	11.5	14.7	12.0	8.2
14	74.6	65.0	15.4	14.0	14.4	12.7
15	87.7	83.6	19.8	16.0	15.5	17.1
16	108.2	71.0	25.7	15.6	22.3	16.0
17	98.1	91.7	23.0	20.7	19.1	15.3
18	117.2	95.0	25.1	16.0	24.4	20.3
19-21	116.7	83.3	22.6	13.7	23.7	18.3
22-24	82.5	75.0	14.0	14.0	17.8	13.3
25-29	81.9	70.0	12.7	7.7	19.7	18.3
30-34	90.0	65.0	14.3	11.6	21.5	18.4
35-39	87.2	70.0	12.8	10.5	21.1	19.0
40-44	93.4	74.3	12.4	11.5	22.6	17.2
45-49	79.0	40.7	11.6	5.7	17.5	9.7
50-54	80.0	47.5	10.8	1.5	20.1	16.5
55-59	76.5	51.7	8.9	2.7	20.5	20.0

*The classification of the cases in this table into those living in or near a town *vs.* those living in more remote districts is based on a personal acquaintance with the homes; cases have been omitted in which home visits had not been made, or in which classification was difficult because of a "border-line" residence.

ual tests of the Stanford-Binet (17). In the case of the Army Alpha, we lack a comparable group of urban adults for a study of the significant problem of urban-rural differences as a function of age. Within our rural sample, however, it is possible to classify many of our cases as living (*a*) in or near a village, or (*b*) in remote and relatively inaccessible rural districts. Table 4 presents mean scores for these two groups in the total Alpha test and in Tests 7 and 8 (medians and standard deviations are given in Appendix A). The more remote rural group is clearly inferior. Does the degree of inferiority increase with age? Table 5 pre-

TABLE 5
RELIABILITY OF THE DIFFERENCE IN ALPHA PERFORMANCE OF
RESIDENCE GROUPS*

Age group	Total Alpha		Test 7		Test 8	
	Mean diff.	Reliability index	Mean diff.	Reliability index	Mean diff.	Reliability index
10-14	10.3	3.7	2.3	2.9	3.5	6.1
15-24	14.4	2.8	6.4	4.3	2.0	1.7
25-39	17.7	3.3	3.4	3.0	2.0	1.6
40-59	27.9	4.8	6.5	6.6	5.2	4.1
10-59	14.3	6.9	4.1	8.1	3.3	7.4

*In each case, the mean score of those residing in remote districts has been subtracted from the mean score of those residing in or near a village or town. The derivation of the figures in the table may require a word of explanation. The basis of the present table is to be found in Tables 4, 6, and 8. For each of the 18 age groups in these tables, we obtained the mean difference (village *minus* remote) and the P.E. of this difference by the usual formula (10, p. 133). Then, for the group including the ages 10, 11, 12, 13, and 14, the mean difference at each age was weighted inversely as the square of its P.E. and the weighted mean difference for the group aged 10-14 was thus obtained (cf. 19, p. 325). (The weighted mean difference is given in the table above, under the heading, "Mean diff.") A similar procedure was employed to obtain the weighted mean difference for the groups aged 15-24, 25-39, 40-59, and 10-59, respectively. The P.E. of the weighted mean difference was then obtained by the formula recommended by Scarborough (25). The reliability index is the weighted mean difference divided by its P.E. The reliability indices indicate superiority on the part of those residing in or near a village or town.

sents the data for combined age groups. In terms of means, some more or less irregular increase of difference is detectable, but in terms of the reliability index the increase is hardly great enough to justify us in stating that the older residents of isolated districts show a reliably greater retardation. It is worthy of note that, with the exception of early adolescence, the differences in Test 7 (analogies) equal or exceed those in Test 8 (general information). This suggests that the "village" and the "remote" samples are genuinely to be distinguished on the basis of selection, and not wholly on the basis of environmental handicap in social contacts and in acquiring information. The facts suggest that selective emigration occurs from farm to village somewhat as it occurs between the general rural community and cities.

In variability (Appendix, Table 8), the remote group tends to be lower than the village group during adolescence; in maturity, however, no consistent variability differences appear. In each group, the period of maximum variability (both absolute and relative) appears to be in the thirties and early forties.

B. SEX DIFFERENCES

A discussion of sex differences is presented elsewhere (6), with a tabulation of means, medians, and standard deviations at each age for each sex. The findings of this investigation may be summarized as follows (6):

"A general slight superiority of females to males is observed; this superiority (as in physical growth curves) is greater during early adolescence, but is at no age suffi-

ciently marked to be of great practical significance. The sex difference is by no means uniform among the individual subtests of the Alpha. In four strongly verbal tests ("common sense," opposites, disarranged sentences, and analogies) the males are rather consistently inferior; in two tests (numerical completions and general information), the sex differences are relatively slight, with frequent intersections of the developmental curves; in one test (arithmetic problems), the males are rather definitely superior . . . The male superiority [in arithmetic] is probably an illustration of a sex difference which has been reinforced by differential practice and mental attitude (4)."

Figure 6 (page 250) gives a comparison of the male and female developmental curves for the two subtests in which sex differences are most marked.

SUMMARY

1. The sample derived from remote and relatively inaccessible rural districts makes consistently lower scores in the Army Alpha than that derived from village and near-village communities. With the exception of early adolescence, the differences in Test 7 (analogies) equal or exceed those in Test 8 (information). This suggests that the "village" and "remote" samples are genuinely to be distinguished on the basis of selection, and not wholly on the basis of environmental handicap.

2. Sex differences are discussed more fully in a separate article (6). In general, differences are comparatively slight but in favor of females (except in Test 2, arithmetic). The female superiority tends (as in physical growth curves) to be greatest during early adolescence.

IV

THE PROBLEM OF DIFFERENTIAL GROWTH AND DECLINE

The comparative growth curves for bright and dull subjects can to some extent be inferred from the standard deviations at each age. More rapid growth of bright than of dull children would cause an increase in the standard deviations from age to age; this increase in standard deviations during adolescence is observable, not only for the total Alpha test, but for each individual subtest (though in varying degrees) (cf. Table 3, pages 251-252). An interesting question concerns the differential duration of growth: If the dull adolescents continued to improve longer than the bright, we should observe a drop in the standard deviations around the peak of development of the total group; on the other hand, if the bright continued to improve longer, we should observe a rise. In point of fact, there is not, in general, any clear evidence for differential duration of growth. Tests 1 and 5 show drops in magnitude of standard deviation after the peak of development (of the total group), but these are followed by rises, and we suspect the drops to be due principally to fluctuations of sampling. Test 6 shows a rise, followed by a substantial drop and subsequent rise. In Test 7, however, the standard deviations increase fairly regularly to the age of 20, after which there is a clear and pronounced decline. It will be recalled (Figure 6) that the peak of development in Test 7 occurs at 17 years. The evidence, then, does indicate a differential duration of growth for this particular test.

Differential decline in mental ability would be indicated either by decreasing S.D.'s (convergence of ability) or increasing S.D.'s (divergence of ability). Both types occur: In Test 2 clearly, and in Tests 4 and 5 somewhat less clearly, the standard deviations rise in maturity. We seem to have here a case of increasing divergence between the bright and the dull. In Test 3, on the other hand, and even more so in Test 7, the standard deviations decline; in these functions, decreasing disparity appears to be the rule. In Tests 1 and 6, the course of the S.D.'s is too irregular to permit any conclusion. In Test 8 and in total Alpha, the S.D.'s in maturity remain fairly constant, indicating the absence of differential development.

Our conclusion concerning the absence of differential decline in the total Alpha test is supported by the results of Miles and Miles (22) for an abbreviation of the Otis Self-Administering Test of Intelligence (Higher Examination, Form A). It is, however, clear that some evidence of differential decline exists in the case of certain individual subtests of the Alpha.

Price (23, pp. 11-13) has interpreted uniformity of standard deviations from age to age as evidence for a differential, rather than a non-differential, rate of decline. He argues that the death-rate, being selective with respect to intelligence, tends progressively to contract S.D.'s in the upper ages; observed uniformity of S.D.'s would therefore imply some expanding influence, such as a different rate of decline for the brighter and the duller portions of the sample, respectively. In the case of the present rural group, however, devoted largely to agriculture and aged only up to 60 years, we may question the importance of a selective death-rate. The contraction of S.D.'s from this source, at any rate, may readily be assumed to be counterbalanced by the expansion of S.D.'s through the growing divergence

observable between the mean scores of males and of females (6).

Question may arise as to the statistical nature of the differential growth during adolescence, and the differential decline in certain individual subtests during maturity. Do the bright children advance faster than average, or do the dull advance slower, or do both phenomena occur? From the S.D.'s alone, it is not possible to answer this question. Previous research on the constancy of the IQ, however, has indicated that the bright advance more rapidly than average, and the dull less rapidly. We may perhaps assume similar results for the bright and dull groups in the case of differential development during maturity; our data are hardly sufficient to warrant a direct examination of the question.

The discussion above has implicitly assumed that scores in the total Alpha test and in the various subtests are in terms of equal units. The tolerably linear relation between T-scores and raw scores (Appendix, Table 16) encourages the belief that this equal-unit requirement is sufficiently fulfilled; in the case of scores for the total Alpha test, we may feel fairly certain that it is fulfilled (pages 288-291).

As we have noted in Appendix B, the S.D.'s in Table 3 (forming the basis for the present discussion) are probably adequately comparable from age to age, so far as test reliability is concerned; but since zero scores are not uniformly distributed from age to age (Table 15), the effect of this factor is to depress the S.D.'s at the younger and later ages somewhat below their true comparative values.

It is interesting to note that fulfillment of Thurstone's law of absolute variability (30) would require that the decline in intelligence-test scores be accompanied by corresponding decline in absolute standard deviations—implying more rapid decline of intelligence among the brighter than among the duller of the adults. Using raw Alpha scores, we have failed to obtain a general linear relationship between mean and standard deviation (cf. Table 3, pages 251-252). Whether or not the same absence of a general relationship would be found with Alpha scores in "absolute" scaling remains to be determined.

It must be emphasized, in conclusion, that the discussion above does not attempt to give more than a rough picture of what seems to be true on the average.

We do not deny the possibility—and history can supply the instances—of brilliant men maintaining their mental capacities in full power until advanced old age. Such men are fortunate exceptions to the general rule. Other exceptions, some not so fortunate, also doubtless occur. A study of these exceptions is unquestionably of very great importance, but would require continuous information for each individual from the cradle to the grave. It is indeed to be hoped that the collection of such information, by adequate tests, may very soon be undertaken.

SUMMARY

1. The comparative growth curves for bright and dull subjects can to some extent be inferred from the standard deviations of test scores at each age.

2. In adolescence, a differential rate of growth (as between bright and dull) is clearly indicated by the increase in the standard deviations of scores from age to age. This increase occurs not only for total Alpha, but for every single subtest of the Alpha.

3. There is little evidence for a differential duration of growth as between the bright and the dull groups.

4. Differential decline seems to occur in Tests 2, 4, and 5 (divergence of ability) and in Tests 3 and 7 (convergence of ability). In Test 8 and in total Alpha, the S.D.'s in maturity remain fairly constant from age to age, indicating the absence of differential development.

5. Our generalizations concerning the presence or absence of differential development, on the average, must not be applied indiscriminately to individual instances.

V

SUMMARY

1. The present study attempts primarily to trace the growth and decline of mental-test ability between the ages of 10 and 60 years. The data consist of Army Alpha intelligence tests of 1191 unselected subjects in central and northern New England.

2. To insure fairness of sampling, a technique was developed involving a free motion-picture show and supplementary house-to-house testing.

3. The chief characteristics of the developmental curve for the total Alpha test may be summarized as involving a linear growth to about 16 years, with a negative acceleration beyond 16 to a peak between the ages of 18 and 21. A decline follows which is much more gradual than the curve of growth, but which by the age of 55 involves a recession to the 14-year level.

4. The developmental curves for the individual subtests of the Alpha display important differences among themselves. In some tests, the adolescents are superior to most of the adults; in others, the adults, on the average, surpass the adolescents. In some tests, the peak of development is reached around 18 years; in others, a slight rise continues well into advanced maturity. In some tests, the decline beyond the maximum is fairly precipitous; in others, it is practically negligible. It is noteworthy that the tests of information (Test 4, opposites or vocabulary, and Test 8, general information) fail to exhibit a post-adolescent decline. Decline is most rapid in Subtests 7 (analogies), 3 ("common

sense"), and 6 (numerical completions). These tests may perhaps be considered, at least on *a priori* grounds, to be the best in the Alpha for the measurement of basic intelligence or intellectual capacity.

5. The sample derived from remote and relatively inaccessible rural districts makes consistently lower scores in the Army Alpha than that derived from village and near-village communities. Since the inaccessible districts are no more inferior in Test 8 (general information) than in Test 7 (analogies), it is probable that the "village" and "remote" samples are genuinely to be distinguished on the basis of selection, and not wholly on the basis of environmental handicap.

6. A general slight superiority of females to males is observed (except in Test 2, arithmetic). This superiority (as in physical growth curves) is greater during early adolescence.

7. In adolescence, a differential rate of growth (as between bright and dull) is clearly indicated by the increase in the standard deviations of scores from age to age. This increase occurs not only for total Alpha, but for every single subtest of the Alpha. There is no clear evidence, however, for a differential duration of growth. Differential decline seems to occur in Tests 2, 4, and 5 (divergence of ability), and in Tests 3 and 7 (convergence of ability). In Test 8 and in total Alpha, the S.D.'s in maturity remain fairly constant from age to age, indicating the absence of differential development.

8. The decline of ability beyond the age of 21 is not due to errors of sampling. In fact, the post-adoles-

cent decline is especially marked in the developmental curve for the group of towns most intensively sampled; and also in the curve for the "complete-family" group, in which homogeneity of sampling seems specifically assured.

9. The decline of adult ability beyond the age of 21 is not due to faulty administration of the Alpha. Examinations administered in the homes of the subjects, under conditions closely approximating those of individual testing, lead to the same conclusion as the group tests.

10. The decline of ability in the total Alpha test, and the peculiarities of the developmental curves for the individual subtests, cannot be successfully explained by failure of motivation, remoteness of schooling, lack of understanding of directions, disproportion in attention to accuracy versus speed, lack of practice in the test functions, failing hearing, or failing eyesight.

11. From the point of view of measuring basic or native intelligence, the information tests of the Alpha (Tests 4 and 8) present an unfair advantage to those in the upper age brackets. Exclusion of Tests 4 and 8 from the Alpha gives a picture of comparatively more rapid growth among the adolescents and more rapid decline among the adults.

12. In the sixth decade of life, about 40% of total Alpha score is derived from two tests (Test 4 and Test 8); at age 10, these tests contribute only 25%. As represented in mental tests, then, the effective intellectual power of the adult, much more than that of the

10-year-old, is evidently derived from accumulated stocks of information.

13. We have not attempted to do more than generalize concerning the growth and decline of mental abilities. Sweeping application of the average results to individual cases would be dangerous and ill-advised. It is true, as Thorndike has remarked in his discussion of the data of the present monograph, that within the age range of the present sample of adults, "individual differences amongst those of the same age . . . enormously outweigh differences between ages . . ." (29). It is also probably true that some individuals, whether through good fortune of endowment or circumstance or care, are able for many years to forestall the decline which ordinarily takes place with the passage of years. Such individuals are fortunate exceptions to the rule. Other exceptions, some not so fortunate, also doubtless occur. The present study, however, is concerned with the average and not with the exception. Without attempting in the least to minimize the importance of considering each person by himself, we may still be interested in the psychological and social implications which are indicated in our curves of average decline.

APPENDIX A

THE SAMPLE

The validity of the present research rests upon the fairness and homogeneity of sampling. It has seemed desirable, therefore, to give a fairly full comparative description of the various subdivisions of the sample. Table 6 gives the number of cases in each age group for the total sample and for the various subdivisions (see pages 242-247 for definition of these subgroups). Tables 7-9 present statistical constants.

In most of our tabulations we have combined the data from our two samples in central and northern New England. For justification of this we refer the reader to Tables 10-12, which give some indication of the comparability of these two geographic groups; these tables also serve to illustrate the consistency of our sampling procedure. It is realized that Tables 10 and 11 do not completely describe either the Northern or the Central New England group; they do, however, present data of considerable importance from the point of view of sampling (as has been shown in Figures 1, 2, and 4). The differences between the Northern New England and the Central New England cases in Table 12 are clearly unreliable in the age range 16-59; though for the age group 10-15 the difference does appear to be reliable by the conventional criterion. It may be well, here, to remember Yule's caution concerning the obtained probable errors of values not known *a priori* (33, p. 277); certainly if we employed Yule's suggestion and obtained the "limiting value" of the P.E., no reliable difference would be found. At any rate, the difference in the age group 10-15 is not very great (considerably less than half a standard deviation), nor does it occur in a portion of the growth curve receiving much attention in the present study. For this reason, and in view of the facts of Tables 10 and 11, we have felt justified in combining cases from all sources into a single sample.

A comparison between the "partial-family" and the "non-family" groups shows that they are similarly sampled with respect to the proportion of group-tested and of home-tested cases (Table 13), and that they give similar growth curves in total Alpha (Figure 5, page 246). These facts appear to justify the combination of these two groups in Table 14, and elsewhere.

TABLE 7
STATISTICAL CONSTANTS (MEAN, MEDIAN, AND S.D. OF RAW SCORES) OF VARIOUS DIVISIONS
OF THE TOTAL SAMPLE*

Age group	Total sample			"Complete-family"			"Partial-family"			"Non-family"		
	Mean	Med.	S.D.	Mean	Med.	S.D.	Mean	Med.	S.D.	Mean	Med.	S.D.
10	44.4	42.5	23.5	38.8	41.3	21.0	50.0	45.0	25.0	45.0	42.5	23.1
11	46.8	50.5	23.4	53.6	56.7	22.0	43.4	51.0	19.3	45.5	40.0	26.4
12	56.7	52.5	23.4	58.5	55.0	23.7	59.1	52.5	21.4	48.6	52.0	18.4
13	60.5	57.5	27.0	35.9	52.5	21.7	67.5	65.0	28.6	57.9	58.0	28.4
14	75.7	80.8	28.3	80.6	80.0	28.9	72.0	81.0	31.3	76.2	80.7	22.2
15	35.7	35.6	32.3	85.8	90.0	28.1	94.3	95.0	28.5	73.0	73.3	35.6
16	93.5	91.0	39.0	96.9	92.5	40.3	90.9	85.0	41.5	93.1	93.3	36.0
17	96.6	92.5	38.0	102.7	97.5	40.2	85.8	80.0	38.8	98.6	92.5	35.3
18	97.0	92.0	41.6	113.0	110.0	50.8	97.5	93.3	28.3	90.0	80.0	41.1
19-21	100.7	92.8	45.5	117.0	120.0	48.7	82.0	77.5	37.0	105.2	96.0	44.5
22-24	91.8	90.0	41.6	125.3	120.0	36.3	103.2	112.5	44.5	80.2	77.0	36.3
25-29	90.5	87.0	38.6	81.2	85.0	37.1	97.3	102.5	46.4	91.0	86.5	36.7
30-34	37.0	80.9	44.0	75.4	75.0	33.0	95.3	100.0	45.6	90.1	83.0	46.4
35-39	85.1	84.0	42.5	69.1	61.7	35.6	96.0	96.7	44.5	96.1	95.0	42.4
40-44	92.2	90.6	44.7	32.9	91.3	46.3	90.8	85.0	41.0	100.8	100.0	43.5
45-49	80.7	74.0	39.3	71.4	70.0	36.0	85.8	85.0	40.9	89.6	80.0	44.8
50-54	81.3	71.3	43.1	79.6	60.0	46.3	85.0	90.0	44.7	80.8	68.8	36.6
55-59	78.6	72.5	40.1	80.0	83.5	35.5	71.7	65.0	33.7	81.7	70.0	44.0

TABLE 7 (continued)

Age group	Extensive sampling			Intensive sampling			Group-tested cases			Home-tested cases		
	Mean	Med.	S.D.	Mean	Med.	S.D.	Mean	Med.	S.D.	Mean	Med.	S.D.
10	49.0	45.0	26.3	57.9	40.0	16.7	46.5	43.3	23.0	37.5	40.0	23.9
11	45.9	47.5	24.7	48.2	52.0	21.2	48.1	52.5	22.6	41.0	30.0	25.8
12	55.3	51.0	23.6	57.9	54.0	23.2	56.3	55.5	22.7	59.0	45.0	27.3
13	67.2	63.8	23.8	51.3	48.3	25.8	62.5	61.0	28.3	54.4	52.0	21.5
14	77.3	80.6	26.0	73.8	81.0	30.9	79.8	83.1	26.5	51.3	55.0	26.9
15	83.6	81.3	33.5	88.8	90.0	30.3	85.0	85.0	32.6	90.0	90.0	30.4
16	96.0	88.6	39.3	90.5	93.8	38.4	97.8	97.0	38.3	66.0	75.0	31.1
17	90.6	87.5	36.8	107.2	105.0	37.8	97.0	90.0	39.6	93.3	95.0	22.7
18	98.1	92.5	41.6	93.0	85.0	41.4	93.8	88.3	39.3	123.0	125.0	50.0
19-21	97.3	88.8	42.6	106.2	110.0	49.0	100.1	92.2	45.1	103.2	105.0	46.7
22-24	91.5	82.5	40.9	92.7	97.5	43.2	90.3	85.0	42.8	107.5	115.0	20.5
25-29	96.7	93.8	39.3	80.6	78.3	35.3	95.0	89.3	39.8	82.1	81.7	33.4
30-34	88.6	81.0	39.9	84.2	80.8	50.2	87.8	81.4	44.3	85.0	80.0	43.4
35-39	86.5	85.7	41.1	84.1	82.5	43.2	90.2	90.0	40.6	79.1	74.0	43.5
40-44	102.3	93.3	40.2	78.4	88.5	46.9	105.9	100.0	41.2	67.3	67.5	41.6
45-49	84.6	80.8	39.0	72.1	67.5	38.6	90.6	86.0	38.7	53.3	55.0	25.2
50-54	87.6	87.5	39.5	74.3	57.5	45.7	89.3	87.5	41.6	69.6	55.0	42.4
55-59	74.5	70.0	35.3	85.0	81.7	45.9	85.0	81.3	42.3	58.8	55.0	22.9

*For a detailed description of the various divisions of the sample see pages 242-247 and Tables 6, 14, and 14a.

TABLE 8
STATISTICAL CONSTANTS (MEDIAN AND S.D. OF RAW SCORES) OF RESIDENCE GROUPS*

Age group	Total Alpha			Test 7			Test 8		
	Residence		Remote S.D.	Residence		Remote S.D.	Residence		Remote S.D.
	Village Median	Village S.D.		Village Median	Village S.D.		Village Median	Village S.D.	
10	46.0	21.1	22.5	9.4	6.94	.8	1.89	9.5	4.95
11	52.5	24.8	55.0	10.9	7.48	11.0	2.24	7.0	6.58
12	57.5	23.2	40.0	14.6	6.13	9.0	5.16	12.0	7.00
13	51.8	26.8	52.5	24.1	9.5	7.58	14.0	10.5	6.23
14	81.3	29.0	55.0	21.6	14.0	8.29	14.0	12.7	7.97
15	90.0	28.3	87.5	21.0	19.0	8.70	19.5	15.0	6.85
16	110.0	39.1	65.0	35.0	27.4	8.97	14.0	21.0	8.53
17	95.0	31.6	115.0	40.3	25.0	9.38	24.0	20.0	8.69
18	105.0	44.2	80.0	45.5	26.0	10.71	12.0	24.5	9.60
19-21	117.5	46.2	60.0	47.8	25.3	12.45	8.0	19.0	10.56
22-24	90.0	39.3	75.0	40.8	10.0	10.86	12.0	9.09	14.0
25-29	81.0	32.2	65.0	28.1	10.4	7.80	7.0	20.5	8.58
30-34	81.7	47.7	46.7	39.5	10.4	11.73	7.0	20.7	10.40
35-39	86.7	46.4	60.0	34.5	12.0	9.40	9.0	23.0	10.56
40-44	92.5	45.4	65.0	49.6	7.8	10.93	5.0	23.8	9.91
45-49	77.5	30.3	25.0	40.0	10.3	8.63	.9	18.3	8.54
50-54	65.0	44.5	40.0	29.5	7.0	11.15	1.7	19.0	10.67
55-59	75.0	35.7	37.5	23.6	7.5	6.87	.8	13.0	10.02

*See also Table 4, page 263.

TABLE 9
MEAN SCHOOLING RECEIVED BY VARIOUS DIVISIONS OF THE SAMPLE (IN TERMS OF LAST GRADE ATTENDED)* FOR COMBINED AGE GROUPS

Age group	Total sample		Male		Female		Group A: Extensive sampling		Group B: Intensive sampling		Hall- tested cases		Home- tested cases	
	n ^a	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean
10-15	306	7.2	143	7.2	162	7.4	167	7.4	139	7.3	250	7.4	55	6.8
16-21	222	10.1	117	9.9	105	10.4	137	10.0	85	10.4	139	10.2	34	10.4
22-39	259	9.6	121	9.3	138	9.9	145	9.9	114	9.3	175	9.7	86	9.6
40-59	154	9.8	73	10.0	81	9.6	86	10.4	68	9.0	96	10.2	56	8.9
Total	941	...	454	...	486	...	406	...	555	...	710	...	231	...
Age group	"Complete-family" group		"Partial-family" group		"Non-family" group		Residence group		Unclas- sified					
	n	Mean	n	Mean	n	Mean	Village	Remote farms	n	Mean	n	Mean	n	Mean
10-15	87	7.1	127	7.6	91	7.0	129	7.4	30	7.2	147	7.3		
16-21	59	10.5	58	9.4	106	10.4	71	10.5	16	9.7	135	10.0		
22-39	70	8.6	41	9.7	150	10.2	116	9.7	25	8.3	118	9.9		
40-59	59	9.5	41	9.3	52	10.3	84	9.9	18	8.0	52	10.1		
Total	275	...	267	...	399	...	400	...	89	...	452	...		

*The *n*'s in the table refer to the number of cases in each division of the sample who reported the last grade attended. Grades of schooling were counted as follows: Last grade of elementary school, 8; last grade of high school, 12; graduation from college, 16; intermediate grades were assigned corresponding numerals. As can be seen from the first two columns of the table, 413 cases aged 22 or over reported their education. The distribution of schooling for these 413 cases, from grade 0 to 17 inclusive, is as follows: 3, 0, 0, 2, 5, 10, 14, 15, 136, 58, 20, 17, 88, 6, 13, 1, 24, 1.

TABLE 10
PERCENTAGE OF CASES IN EACH AGE GROUP FOR CENTRAL AND
FOR NORTHERN NEW ENGLAND SAMPLES*

Sample	Age group								
	10	11	12	13	14	15	16	17	18
Northern New Eng.	2.1	4.1	4.8	6.8	5.4	5.1	6.2	3.8	4.3
Central New Eng.	4.5	5.8	6.8	4.2	3.2	5.3	6.6	5.0	2.9

	Age group								
	19-21	22-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59
Northern New Eng.	7.5	3.5	7.3	8.9	8.8	8.3	5.9	4.9	2.4
Central New Eng.	6.8	4.2	7.6	8.9	6.6	7.9	5.3	5.0	3.7

*For enumeration of the towns included in these samples see Table 6.

TABLE 11
PERCENTAGE OF INDIVIDUAL VS. GROUP TESTS IN COMBINED AGE
GROUPS FOR CENTRAL AND FOR NORTHERN NEW
ENGLAND SAMPLES*

Age group	Northern New England		Central New England	
	Group tests	Individual (home) tests	Group tests	Individual (home) tests
10-15	82	18	82	18
16-21	85	15	85	15
22-39	71	29	69	31
40-59	68	32	70	30
Total	76.4	23.6	76.6	23.4

*For an enumeration of the towns included in each of these samples see Table 6.

TABLE 12
RAW ALPHA SCORES OF CENTRAL AND OF NORTHERN
NEW ENGLAND SAMPLES*

Age group	Northern New England			Central New England		
	n	Mean	Median	n	Mean	Median
10-15	229	66.6	63.6	113	55.6	49.1
16-21	177	99.5	92.3	81	92.2	91.9
22-39	230	89.0	84.6	104	85.8	84.0
40-59	174	84.3	82.8	83	86.3	77.2

*For an enumeration of the towns included in each of these samples see Table 6.

TABLE 13
COMPARISON OF PARTIAL- AND NON-FAMILY GROUPS

	Group A: Extensive sampling		Group B: Intensive sampling		Total sample	
	Partial- family cases	Non- family cases	Partial- family cases	Non- family cases	Partial- family cases	Non- family cases
Adolescents (ages 10-21)						
Group-tested	95.8	100.0	77.3	91.5	90.0	97.4
Home-tested	4.2	...	22.7	8.5	10.0	2.6
Adults (ages 22-59)						
Group-tested	97.3	94.3	48.9	52.3	79.0	82.0
Home-tested	2.7	5.7	51.1	47.7	21.0	18.0
Total						
Group-tested	96.3	96.7	65.8	70.1	86.0	88.7
Home-tested	3.7	3.3	34.2	29.9	14.0	11.3

Table 14, which is to be read in columns—not rows—gives a summary description of the sample, divided into "adolescents" (aged 10-21) and "adults" (aged 22-59). Extended comment on this table is not possible; the careful reader will note for himself that the males and females appear to be sampled quite similarly; that most of the individual testing (especially among the adults) was done in Group B; that most of the persons whose residence is unknown were group-tested;¹⁵ that Group A includes relatively few in the "complete-family" category; etc.

In Table 14a we present a more complete description of the sample. This table gives, by age groups, the number of cases in various combined classifications (e.g., the number of cases in Group B who are male and half-tested, male and home-tested, etc.).

APPENDIX B

STATISTICAL TECHNIQUE

Statistical Constants. The statistical constants with which we are concerned are the mean, the median, and the standard deviation. Of

¹⁵The slight percentage of home-tested persons whose residence is unknown consists principally of visitors to the home in which the testing was done.

TABLE 14 (continued)
Ages 22-59

	n	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
12 Group A	345	58	..	..	60	58	77	17	34	42	87	55	68			
13 Group B	245	42	..	..	40	42	23	83	66	58	13	65	32			
14 Male	272	46	47	45	..	..	45	48	47	48	45	51	44			
15 Female	318	54	55	55	..	..	55	52	53	52	55	49	56			
16 Group-tested	410	69	91	39	68	71	..	..	45	48	99	42	81			
17 Home-tested	180	31	9	61	32	29	..	..	56	52	1	58	19			
18 Village	265	45	26	71	46	44	29	82	..	..	..	65	36			
19 Remote farms	60	10	7	14	11	10	7	17	..	..	..	21	6			
20 Unclassified	265	45	67	14	44	46	64	1	..	..	..	14	58			
21 Complete-family	176	30	18	47	33	27	18	57	45	62	9	..	..	
22 Partial- and non-family	414	70	82	53	67	73	82	43	57	38	91	..	..	

*Excluding three cases for whom information concerning sex was not available.—The table is to be read in columns—not rows. Thus, in the age group 10-21, of the total males, 63% are in Group A, 57% are in Group B (column 6); note that the percentage of males in Group A is not 55, and in Group B is not 47 (line 5). The figures 55 and 47 refer to the percentage of Group A which is male, and the percentage of Group B which is male, respectively.—Similarly, of the total number group-tested, 66% are in Group A, 34% are in Group B (column 8); of the total number tested in homes, 73% belong to the "complete-family" group, 27 to the "partial- and non-family" group; etc.

TABLE 14a
DETAILED DESCRIPTION OF THE SAMPLE*

Age Group	Group 1: Extensive Sampling																							
	Male												Female											
	Group-Tested						Group-Tested						Group-Tested						Group-Tested					
	Village			Rural			Village			Rural			Village			Rural			Village			Rural		
	Com-plate	Pro-plate	Non-plate	Com-plate	Pro-plate	Non-plate	Com-plate	Pro-plate	Non-plate	Com-plate	Pro-plate	Non-plate	Com-plate	Pro-plate	Non-plate	Com-plate	Pro-plate	Non-plate	Com-plate	Pro-plate	Non-plate	Com-plate	Pro-plate	Non-plate
	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested
	Total						Total						Total						Total					
	10-15	16-20	21-25	26-30	31-35	Total	10-15	16-20	21-25	26-30	31-35	Total	10-15	16-20	21-25	26-30	31-35	Total	10-15	16-20	21-25	26-30	31-35	Total
	1	10	1	—	2	14	5	—	—	—	—	5	7	12	—	2	2	21	11	8	2	3	—	—
	4	3	3	2	8	20	1	2	—	—	—	3	4	4	2	1	8	63	1	2	1	—	—	—
	6	12	1	4	4	27	2	1	—	—	—	3	4	3	3	8	1	64	87	3	3	—	—	—
	4	13	2	3	6	28	5	1	—	—	—	13	8	12	3	2	8	63	5	2	—	—	—	—
Total	15	48	7	9	20	109	15	4	—	—	—	23	19	27	9	13	31	253	16	11	4	—	—	—
Group 2: Limited Sampling																								
Age Group	Male												Female											
	Group-Tested						Group-Tested						Group-Tested						Group-Tested					
	Village			Rural			Village			Rural			Village			Rural			Village			Rural		
	Com-plate	Pro-plate	Non-plate	Com-plate	Pro-plate	Non-plate	Com-plate	Pro-plate	Non-plate	Com-plate	Pro-plate	Non-plate	Com-plate	Pro-plate	Non-plate	Com-plate	Pro-plate	Non-plate	Com-plate	Pro-plate	Non-plate	Com-plate	Pro-plate	Non-plate
	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested	Tested
	Total						Total						Total						Total					
	10-15	16-20	21-25	26-30	31-35	Total	10-15	16-20	21-25	26-30	31-35	Total	10-15	16-20	21-25	26-30	31-35	Total	10-15	16-20	21-25	26-30	31-35	Total
	6	12	8	—	2	28	11	14	5	4	—	30	4	3	1	1	10	19	8	4	3	1	—	—
	7	7	1	1	2	18	5	8	4	1	—	18	4	12	1	—	11	35	9	2	5	—	—	—
	1	9	1	—	2	13	15	14	3	1	—	33	6	14	1	—	8	31	19	24	—	2	—	—
	6	7	2	—	1	16	18	9	7	—	—	34	3	9	1	—	1	22	12	9	2	1	—	—
Total	20	35	12	3	7	77	49	39	17	6	—	123	18	38	4	1	31	115	48	19	11	4	—	—
Grand Total	34	79	20	10	19	186	64	77	22	7	—	157	37	55	15	2	42	268	64	30	15	4	—	—

*Excluding three cases for whom information concerning sex was not available.

†"Partial-family" group and "non-family" group.

‡"Complete-family" group.

TABLE 15
PERCENTAGE OF ZERO OR NEGATIVE SCORES IN ALPHA SUBTESTS

Age group	No. tested	Percentage of zero or negative scores in Alpha subtest no.																Av. per cent per subtest*		
		1		2		3		4		5		6		7		8				
		Hall	Home	Hall	Home	Hall	Home	Hall	Home	Hall	Home	Hall	Home	Hall	Home	Hall	Home	Hall	Home	Total*
10-13	179 46	2.2	4.4	1.7	2.2	7.8	6.5	15.1	19.6	10.1	6.5	7.3	10.9	8.9	8.7	7.3	4.4	7.5	7.9	7.6
14-17	210 32	1.4	3.1	..	..	2.9	6.3	6.7	15.6	4.3	9.4	3.3	12.5	3.8	9.4	1.4	3.1	3.0	7.4	3.6
18-21	111 22	..	..	..	..	.9	..	3.6	..	5.4	..	6.3	4.6	3.6	4.6	.9	..	2.6	1.1	2.4
22-29	107 25	.9	4.0	..	4.0	3.7	..	8.4	16.0	1.9	4.0	9.4	4.0	4.7	8.0	.9	4.0	3.7	5.5	4.1
30-39	128 74	3.1	1.4	..	2.7	.8	1.4	9.4	13.5	9.4	8.1	10.2	6.8	9.6	4.1	.8	..	5.3	4.7	5.1
40-49	116 49	.9	4.1	1.7	2.0	..	6.1	7.8	20.4	5.2	12.2	5.2	10.2	12.1	10.2	1.7	..	4.3	8.2	5.5
50-59	60 32	..	6.3	1.7	6.3	1.7	9.4	13.3	21.9	6.7	12.5	16.7	15.6	6.7	12.5	..	..	5.8	10.6	7.5
Weighted mean		1.4	3.2	.7	2.5	3.0	4.3	9.1	16.1	6.3	8.2	7.2	9.3	6.9	7.9	2.3	1.4	4.6	6.6	5.1

*Weighted for number of cases tested in homes and in halls, respectively.

these, both the mean and the standard deviation are affected by zero scores. These zero scores are not uniformly distributed throughout the various age groups, being more heavily concentrated at the lower and upper ends of the age range (see Table 15). Inasmuch as a zero score probably denotes a less-than-zero ability (in terms of equal units), correction for this factor would to some extent increase the standard deviations, and would decrease the means, especially for the younger and the older subjects of our sample—in other words, this correction would emphasize both the rise and the decline in the growth curves of Figures 1-6.

Throughout, we employ the "raw" statistical constants. We have not attempted to correct the means and standard deviations for the effect of zero scores; Shepard's correction was not applied to the measures of variability; and raw S.D.'s were not converted into "true" S.D.'s. With regard to this last point, Jones (13) has reported the split-half reliability of the Army Alpha, for an unselected sample of rural New England adults, as .977; and Conrad and Jones, in a similar sample, using two mental tests based on motion pictures, found virtually equal reliability coefficients among both adolescents and adults (2). From these indications it is probable that the raw S.D.'s to be reported for the total Alpha test at least approximate the "true"; and that the raw S.D.'s for both the total Alpha and the individual Alpha subtests are adequately comparable from age to age.

T-Scores. T-scores were resorted to as a means of rendering comparable the statistical constants of the various age groups in the various tests. McCall has recommended the use of the scores of 12-year-olds as the basis of T-scaling (21); we have, however, considered a mature group to be superior for present purposes and have therefore employed the scores of the 290 adults aged 25-39. Figure 8 compares the T-score re-scaling of total Alpha scores with Thorndike's equal-unit re-scaling (28, pp. 237-238); it can be seen that the two curves virtually coincide, except for the dotted portions of the Thorndike curve. These dotted portions represent values suggested only tentatively by Thorndike;¹⁰ the disagreement is insignificant, not only for this reason, but also because only a small frac-

¹⁰The values for Alpha scores of 0-19 are not published, but were suggested by Professor Thorndike in a personal communication.

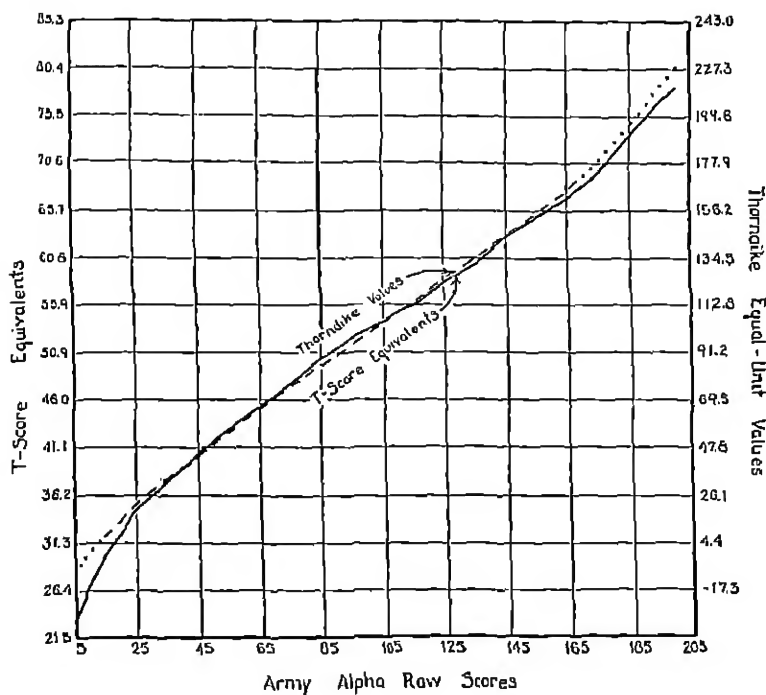


FIGURE 8
RELATION BETWEEN RAW ALPHA SCORES, T-SCORES, AND
THORNDIKE'S EQUAL-UNIT VALUES

tion of raw Alpha scores occur below or above the point at which the dashed lines begin (less than 4% below 20, and less than 3% at or above 170). The slight irregularities in the curve of T-scores may be presumed to be caused, at least in part, by the absence of truly equal units in the base line.

Within our knowledge, no re-scaling of the scores for the individual subtests of Alpha has previously been made; our T-scores for these tests must therefore be presented without comparison. Table 16 presents raw scores and T-score equivalents for total Alpha and each subtest; Table 17 gives the mean, median, and S.D. of the distributions from which the T-score equivalents were obtained.

TABLE 16
T-SCORE EQUIVALENTS OF RAW SCORES

Score in Total Alpha	T-score equivalent	Score in Alpha ^a	T-score equivalent	Score in Test 1	T-score equivalent	Score in Test 2	T-score equivalent	Score in Test 3	T-score equivalent	Score in Test 4	T-score equivalent	Score in Test 5	T-score equivalent	Score in Test 6	T-score equivalent	Score in Test 7	T-score equivalent	Score in Test 8	T-score equivalent
0-9	23.0	0-4	21.2	0	24.5	0	24.5	0	26.2	-7.(-4)	24.5	-3.(-2)	22.9	0	33.2	0	31.1	0	25.5
10-19	30.2	5-9	25.4	1-2	30.5	1-2	33.8	1-2	33.8	-3.0	34.5	-1.0	33.0	1-2	38.9	1-4	39.6	1-4	33.5
20-29	34.8	10-14	30.6	3-4	35.8	3-4	39.3	3-4	39.3	1-4	40.1	1-2	37.0	3-4	42.1	1-4	43.1	5-8	37.0
30-39	38.0	15-19	34.2	5-6	41.0	5-6	44.1	5-6	44.1	5-8	43.8	5-6	38.7	5-6	45.7	5-8	46.9	9-12	41.2
40-49	40.6	20-24	36.5	7-8	47.1	7-8	49.8	7-8	49.8	9-12	47.6	7-8	41.5	7-8	50.4	9-12	51.5	13-16	44.9
50-59	43.1	25-29	39.2	9-10	51.2	9-10	53.6	9-10	53.6	13-16	51.6	9-10	44.6	9-10	56.1	13-16	57.1	17-20	48.5
60-69	45.4	30-34	41.9	11-12	58.5	11-12	62.3	11-12	62.3	17-20	58.2	11-12	47.4	11-12	62.5	17-20	63.3	21-24	52.5
70-79	47.6	35-39	43.9	13-14	61.1	13-14	64.5	13-14	64.5	21-24	61.7	13-14	50.3	13-14	67.7	21-24	68.6	25-28	56.4
80-89	50.3	40-44	46.5	15-16	68.2	15-16	70.1	15-16	70.1	25-28	65.1	15-16	53.1	15-16	70.7	25-28	70.7	29-32	59.7
90-99	52.6	45-49	48.6	17-18	73.6	17-18	73.6	17-18	73.6	29-32	67.5	17-18	56.2	17-18	74.6	29-32	73.6	33-36	64.2
100-109	54.3	50-54	50.8	19	75.8	19	75.8	19	75.8	33-36	71.7	19	59.3	19	77.0	33-36	77.0	37-40	67.9
110-119	56.1	55-59	52.5	10	65.1	10	65.1	10	65.1	37-40	75.7	19	62.7	17-18	74.6	37-40	77.0	41-44	70.7
120-129	58.2	60-64	55.6	11	69.4	11	69.4	11	69.4	37-40	75.7	19	66.8	17-18	74.6	37-40	77.0	45-48	73.6
130-139	60.4			12	79.3	12	79.3	12	79.3	37-40	75.7	19	72.0	17-18	74.6	37-40	77.0	49-52	76.4
140-149	62.9																	53-56	79.3
150-159	65.2																	57-60	82.2
160-169	67.0																	61-64	85.1
170-179	69.8																	65-68	88.0
180-189	72.8																	69-72	90.9
190-199	77.0																	73-76	93.8

^aScore in total Alpha, minus score in Test 4 and score in Test 8.

TABLE 17
STATISTICAL CONSTANTS FOR GROUP AGED 25-39

Statistical constant	Total Alpha	Abbrevi- ated Alpha	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8
Mean	87.4	54.3	6.3	9.1	8.1	14.1	11.6	7.4	13.5	20.4
Median	84.1	50.8	6.2	8.9	8.1	13.4	11.8	7.8	11.1	20.6
S.D.	41.9	24.8	2.69	3.45	3.61	10.3	6.33	3.94	10.0	9.61

To what extent the T-scaling amounts also to a scaling into equal units is uncertain, except in the case of the T-scores of the total Alpha (see Figure 8).

As indicated in the preceding section, we have computed means, medians, and standard deviations for raw scores. These statistical constants represent our fundamental data. To obtain T-score equivalents of the statistical constants derived from raw scores, two methods may be followed: First, *each individual raw score* may be converted into its corresponding T-score, and statistical constants computed for the T-values; or, secondly, the *statistical constants of the raw scores* may be converted *directly*. This second method is valid, provided the relation between raw scores and T-equivalents is linear. In our data, the actual relation tends to curvilinearity at the extremes; but since so few extreme scores occur in practice, we have considered it safe to use the method of direct conversion, which has marked advantages from the standpoint of the amount of statistical labor involved.

We do not wish to be misunderstood in our attitude toward the T-scores. We appreciate that the discrepancies between mean and median in many cases indicate the absence of normality of scores for the group aged 25-39; this means, as we have indicated above, that the T-score technique amounts to a re-scaling of the raw scores; such re-scaling, however, does not invalidate the use of the group aged 25-39 as a point of reference for other age groups. More serious is the objection that the group 25-39 is not as stable and consistent as could be desired in its performance on the different tests (cf. Figure 6), thus rendering T-scores derived from this group of less service for inter-test comparisons. However, the group aged 25-39 is the largest and most stable that we have, and undoubtedly supplies better norms for comparative purposes than any other large, adult group available. It perhaps deserves emphasis that, even if the

growth curves for the various tests are not strictly comparable *inter se*, this in no way impairs the validity of each curve by itself. In the present study, our interest is, in fact, centered mainly upon the individual curves—the conversion to T-scores representing only a more or less incidental refinement, and not a fundamental or essential technique.

The Growth Curves. The curves for growth and decline of Alpha ability might be based on any one of the three conventional measures of central tendency, viz., the mean, the median, or the mode. Since the distribution of test scores is usually somewhat positively skewed, the median is perhaps the most representative and uniformly comparable single measure available. We have, however, preferred to use the arithmetic *average* of the smoothed mean and the smoothed median (the smoothed values at each age being taken from the smoothed growth curves). The purpose of this was twofold: first, the *average* score seemed to give more satisfactory (less irregular) curves of growth and decline than either the mean or the median alone; and, secondly, the use of both the smoothed mean and the smoothed median for obtaining the "average" required that the smoothing of the growth curves be performed both on the mean scores and also the median. Since we smoothed principally by eye,¹⁷ this repetition of the fitting process seemed a useful safeguard against accidental errors.

Some readers may express objection to the procedure of fitting by eye. The arguments against this procedure, and in favor of mathematical fitting, are well known. Unfortunately, the practical and theoretical difficulties in mathematical fitting are seldom appreciated except by those with some experience in this branch of mathematical statistics. In the first place, the mathematical fit is not objective: the choice of type and degree of curve to be fitted is quite subjective, and, in the case of data as rough as ours, not easy; considerable trial and error is necessary before satisfactory fits are obtained. Secondly,

¹⁷The fitting by eye was supplemented by an examination of the plus and minus deviations of the original data from the fitted curve; in general, these deviations (weighted by the number of cases) summed approximately to zero. The least-squares criterion was not applied, because the use of first-power deviations evidently gave better results. The least-squares criterion, of course, is entirely arbitrary (19, p. 160), enjoying its favor in mathematical curve-fitting principally because of its *mathematical* convenience.

as we have just implied, *there is no single, correct mathematical solution*. We hear about "*the least squares solution*," when, as a matter of fact, any given set of data permits of numerous solutions, all depending on the type and degree of curve selected (8, pp. 88-89). Thirdly, satisfactory mathematical fits to original data of the form and roughness of ours are extremely time-consuming; no one without experience in fitting curves of high degree (such as our data would require) can appreciate the labor which a large number of such fits actually involves. Finally, we are not assuming that on the basis of this single study it is possible to lay down any final law as to the growth and decline of human intelligence. Smoothing by eye therefore seemed sufficiently adequate for present purposes, especially since the author who undertook to do the work of smoothing was familiar with least-squares fits, and could presumably approximate them by eye. After all, curve fitting, aside from its mathematical aspects, is not so abstruse and esoteric a process as the mathematical formulae involved in fitting may sometimes suggest!

Some explanation may be needed, however, for our rejection of the simple smoothing offered by the formula $\frac{a + b + c}{3}$. The limitations of this formula are obvious enough, but sometimes unappreciated. Most obviously, the formula fails to provide for satisfactory smoothing of a curve at its two ends. More importantly, the formula $\frac{a + b + c}{3}$ fails to give good results unless the ordinates are closely and equally spaced on the X-axis. Neither of these conditions is fulfilled by our data: for rapid growth compels the use of single age groups at the early ages, and cases are not sufficiently numerous at the upper ages to permit a continuation of this unit. Moreover, the formula $\frac{a + b + c}{3}$ is not strictly suitable unless the true curve is a straight line. Notice, for example, how this formula introduces a constant error of .3 for the series 1, 15, 28, 40, 51, 61, 70, 78, etc. Finally, in curves with a maximum, the formula $\frac{a + b + c}{3}$ always spuriously reduces this maximum; and if the curve is unsymmetrical, spuriously shifts the position of this maximum either to right or to left (depending on the nature of the asymmetry). Surely these deficiencies are sufficient to condemn this particular smoothing formula—and all simple smoothing formulae are, by their nature, subject to the same type of errors.

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LA CROISSANCE ET LA DÉCROISSANCE DE L'INTELLIGENCE: UNE ÉTUDE D'UN GROUPE HOMOGÈNE ENTRE LES ÂGES DE DIX ET SOIXANTE ANS

(Résumé)

Cette étude essaie surtout de tracer la croissance et la décroissance de l'intelligence comme montrée par les tests mentaux chez les sujets entre les âges de dix et soixante ans. Dans ce but, on a fait subir le test mental Army Alpha à 1191 sujets des villages du Vermont, du Massachusetts, et du New Hampshire. Le processus du test a compris l'usage des salles publiques des villages pour les tests collectifs (on a offert une entrée libre à un cinéma pour assurer une bonne assistance); et aussi des examens supplémentaires à la maison de ceux qui n'ont pas assisté aux tests collectifs. On a obtenu ainsi un assez bon choix d'une population rurale âgée de dix à soixante ans.

Les principales caractéristiques de la courbe de développement pour tout le test Alpha, entre les âges de dix et soixante ans comprend en somme une croissance linéaire à environ seize ans, avec une accélération négative après seize ans ou point le plus élevé entre les âges de dix-huit et vingt-et-un. Une décroissance suit, qui est beaucoup moins rapide que la croissance pendant l'adolescence, mais qui comprend à l'âge de cinquante-cinq une diminution au niveau de quatorze ans.

Il existe des différences importantes dans les courbes de développement pour les tests individuels ('sub-tests') de l'Alpha. La décroissance est la plus rapide dans les tests individuels 7 (analogies), 3 ("sens commun"), et 6 (compléments numériques). Peut-être peut-on considérer ces tests, du moins pour des raisons *a priori*, les meilleurs de l'Alpha pour la mesure de l'intelligence fondamentale ou capacité intellectuelle. Dans la sixième décade de la vie, environ quarante pour cent des résultats totaux de l'Alpha dérive de deux tests (test 4, vocabulaire, et test 8, information); à l'âge de dix ans, ces deux tests ne contribuent que vingt-cinq pour cent aux résultats totaux de l'Alpha. Selon les tests mentaux, donc, la capacité intellectuelle efficace de l'adulte, beaucoup plus que celle d'une personne plus jeune, ne dérive évidemment que des quantités accumulées de connaissances et de renseignements.

La décroissance de capacité après l'adolescence dans le test total Alpha, et les particularités des courbes de développement pour les tests individuels, ne peuvent être bien expliquées par un manque de mobiles, l'époque reculée de l'assistance à l'école, un manque de compréhension des directions, une disproportion dans l'attention du sujet plus âgé à la précision et à la vitesse, un manque d'exercice dans les fonctions du test, une moins bonne ouïe, et une moins bonne vision.

On a considéré aussi quelques problèmes subsidiaires dans cette étude. (1) On a constaté que les femmes ont montré une petite supériorité générale aux mâles (sauf dans test 2, calcul). Cette supériorité (comme dans les courbes de croissance physique) est la plus grande pendant la première partie de l'adolescence. (2) Les groupes venant des sections rurales éloignées et relativement inaccessibles ont donné constamment des résultats sur le test d'intelligence moins élevés que ceux des habitants du village. On ne peut expliquer cette différence seulement sur la base du handicap de milieu. (3) Dans l'adolescence, comme entre les intelligents et les bornés, une vitesse différentielle de croissance semble clairement indiquée par la croissance dans les écarts étalons des résultats aux divers âges. On ne trouve aucun clair témoignage d'une durée différentielle de croissance.

Dans quelques tests individuels de l'Alpha (mais non pas dans l'Alpha comme ensemble), la décroissance après l'adolescence semble un peu différentielle—une petite convergence de capacité se montrant dans quelques tests individuels, et une petite divergence dans d'autres.

Bien qu'il ait lieu sans doute des exceptions individuelles à la tendance générale, le fait d'une décroissance générale après l'adolescence semble clairement évident. On peut considérer que les courbes pour la croissance et la décroissance de capacité montrée par les tests mentaux indiquent des problèmes sociaux importants.

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ZUNAHME UND ABNAHME DER INTELLIGENZ: EINE UNTERSUCHUNG AN EINER HOMOGENEN GRUPPE IM ALTER ZWISCHEN ZEHN UND SECHZIG JAHREN

(Referat)

In der gegenwärtigen Untersuchung versuchte man vornehmlich die Zunahme und Abnahme der Leistungsfähigkeit in Intelligenzprüfungen in den Altersgruppen zwischen 10 und 60 Jahren zu erforschen. Zu diesem Zweck untersuchte man 1191 Versuchspersonen in 19 Gemeinschaften in ländlichen Teilen der Staaten Vermont, Massachusetts, und New Hampshire mit der Army Alpha Intelligenzprüfung. Die Gruppenprüfungen fanden in Dorfhallen statt; als besonderer Antrieb, hin zu kommen, diente ein Kinofilm, der frei gezeigt wurde. Nachträglich wurden diejenigen, die zu den Gruppenprüfungen nicht gekommen waren, zu Hause geprüft. Auf diese Weise erhielt man ein ziemlich gutes Exemplar einer ländlichen Bevölkerung im Alter zwischen 10 und 60 Jahren.

Die Haupteigenschaften der Entwicklungskurve, dem gesamten Alpha Test nach, für Altersgruppen zwischen 10 und 60 Jahren, weisen, zusammengefasst, auf eine lineale Zunahme [linear growth] bis zu ungefähr 16 Jahren hin. Nach 16 Jahren folgt dann eine negative Beschleunigung [negative acceleration], die zwischen 18 und 21 Jahren ihren Gipfel erreicht. Nun folgt eine Abnahme die viel allmählicher ist, als der Aufschwung während der Jugendzeit [adolescence], die aber mit Erlangung des 56sten Lebensjahres schon einen Rückgang bis zum Niveau des Vierzehnjährigen erweist.

Es zeigen sich wichtige Unterschiede zwischen den Entwicklungskurven für die einzelnen Teilprüfungen des Alpha Tests. Am raschesten findet die Abnahme statt in den Teilprüfungen 7 (Analogien), 3 ("Gesunder Menschenverstand") ["common sense"], und 6 (Zahlenergänzungen). Diese Teilprüfungen können vielleicht, wenigstens *a priori*, als die geeignetesten der Alpha für die Messung der grundsätzlichen Intelligenz oder der intellektuellen Leistungsfähigkeit. Im sechsten Lebensjahrzehnt stammt ungefähr 40% der in dem Alpha Test erzielten Zahl von zwei Prüfungen (Test 4, Wortschatz; und Test 8, Kenntnisse [information]); mit 10 Jahren tragen diese zwei Tests nur mit 25% zu der gesamten, im Alpha Test erzielten Zahl bei. So wie sie sich in Intelligenzprüfungen zeigt, stammt also die wirksame intellektuelle Kraft des Erwachsenen, augenscheinlich bis zu einem viel höheren Grade als die des jüngeren Menschen, nur aus aufgethäuften Vorräten von Erfahrungen und Kenntnissen.

Die Abnahme an Leistungsfähigkeit in dem gesamten Alpha Test nach dem Jünglingsalter, und die Eigenheiten der Entwicklungskurven für die

individuellen Teilprüfungen lassen sich durch Mangel an Antrieb (motivation), Entfernung des Schulunterrichts, Mangel an Verständnis für die Anweisungen, unverhältnismässig starke Konzentrierung der Aufmerksamkeit der älteren Versuchsperson auf Genauigkeit zu Kosten der Schnelligkeit, Mangel an Übung in den Tätigkeiten des Testes, oder abnehmende Schärfe des Gehörs oder des Sehens nicht erfolgreich erklären.

Es wurden in der gegenwärtigen Untersuchung auch gewisse untergeordnete Aufgaben berücksichtigt. (1) Man fand, dass die weibliche Versuchspersonen im Allgemeinen den männlichen etwas überlegen waren (ausser in dem Test 2, Rechenkunst). Diese Überlegenheit ist, wie die in den physiologischen Wachstumskurven erwiesene, während des frühen Jugendalters eine grössere. (2) Das Revölkerungsexemplar, das aus entfernten und relativ unzugänglichen ländlichen Gegenden erhalten wurde, erzielte in der Intelligenzprüfung durchaus niedrigere Zahlen, als die Einwohner des Dorfes. Dieser Unterschied kann nicht vollständig auf Basis der Nachteile der Umgebung erklärt werden. (3) Die Zunahme in den Normalabweichungen der Zahlen von Alter zu Alter scheint bestimmt auf einen Unterschied zwischen Begabten und Unbegabten unter den Jugendlichen in Bezug auf die Schnelligkeit des Wachstums hinzuweisen. Für einen differenzierenden Unterschied in Bezug auf die Dauer des Wachstums [differential duration] haben wir keinen klaren Beweis. In einigen der Teilprüfungen des Alpha Tests (obwohl nicht im Alpha Test als Ganzes genommen) scheint die nachjugendliche Abnahme [post-adolescent decline] etwas differenzierend zu sein da sich in einigen Teilprüfungen eine geringe Konvergenz und in anderen eine geringe Divergenz zeigt.

Obwohl zweifellos individuelle Ausnahmen der allgemeinen Richtung gegenüber bestehen, lässt sich an dem Bestehen einer nach-jugendlichen Abnahme der Leistungsfähigkeit bei Intelligenzprüfungen kaum zweifeln. Die Kurven der Registrierung des Wachstums und der Abnahme der Leistungsfähigkeit bei Intelligenzprüfungen können als auf wichtige soziale Probleme hinweisend betrachtet werden.

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Figure 1. The effect of the concentration of the inhibitor on the rate of polymerization of α -methylstyrene in the presence of SnCl_4 at 25°C .

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**Child Behavior, Animal Behavior,
and Comparative Psychology**

THE RELATION BETWEEN THE COMPLEX-
ITY OF THE HABIT TO BE ACQUIRED
AND THE FORM OF THE LEARNING
CURVE IN YOUNG CHILDREN*

*From the Institute of Child Welfare,
University of Minnesota*

By
MARION L. MATTSON

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MAZE USED IN MAIN EXPERIMENT

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MARION L. MATTSON

UNIVERSITY OF MINNESOTA
MINNEAPOLIS, MINNESOTA

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I

INTRODUCTION

Recent experimental work with children has tended to stress the importance of structural development and maturation in the learning process. Emphasis has shifted from formal training as a necessary part in furnishing the child with those skills he must possess if he is to function as an efficient adult to the part which normal development plays. Jennings, in speaking of the education of children, says:

"The first rule is one which grown-up human beings in many respects ignore to the great injury of children. Much of the power gained by the young human being as the years pass is not brought to him primarily by training, by learning, by the exercise of the particular faculty involved, . . . but is the mere consequence of unhindered healthy development. After the child reaches a certain stage of development, it can do easily and quickly that which it could not do even with much training at an earlier stage; and this silent unfolding may and should continue throughout life. Training is even harmful when it comes earlier than the development of the power which it tries to train; it must then be classed with the blights which cut off the development of powers" (45, p. 20).

The problem concerning the relative parts contributed by practice or training, provided by the environment, and maturation or development that is determined principally by inner growth factors has important educational implications. In matters of child training, popular belief has changed from time to time, fluctuating between the extreme "hands off" policy wherein

the natural powers are left to develop unhampered by environmental restraints, and the equally extreme policy of a definite formalized system of training intended to suppress and supplant natural tendencies. The prevailing popular opinion does much to determine the educational policy of our schools.

If nature is all-important, education becomes increasingly futile, for it would be a waste of time and effort to attempt to change the unalterable force. If environmental factors are more effective, training in the home and school is essential in preparing the child for meeting the requirements of later life. Psychological and biological studies (6, 12, 20, 44, 81) are attempting to clear up this question, but more work is needed before we can state with certainty what is the exact influence of either factor upon any given ability or skill. It is a most difficult task for, as Marquis (58) points out, these two streams of influence go along together throughout the life of the individual and cannot be clearly separated at any point. Even during the prenatal period, intrinsic and extrinsic factors are acting simultaneously upon the growing organism, and, as development continues, it becomes increasingly more difficult to determine which has the major rôle. If the process of growth and development will bring a given ability to as high a plane of functioning as specific practice, it is useless to subject children to intensive training in that particular ability. The whole question of what to teach, and when and how to teach it, is intimately concerned with this problem.

It is the purpose of this study to investigate the rela-

tive contributions made by practice and maturation together with other influences in the environment in a group of young children who are in a stage of rapid development. The learning situation is to be made up of a series of tasks differing in level of complexity so that learning may be analyzed in relation to this factor. There is need for a study concerning the rôle of maturation and practice at the preschool level in a skill made up of different degrees of complexity.

EXPERIMENTAL LITERATURE

Studies Relating to the Effects of Practice. Most of the experimental work in this field has been carried on with animals or newborn babies, but within the last five years there have been several studies on preschool children.

Gates and Taylor (18), working on a motor and mental function, attempted to test out the three following theories concerning the character and limits of improvement: that improvement results from the direct increase in fundamental capacities; that improvement results from the indirect increase in fundamental capacities by means of stimulated growth; that improvement results from the acquisition of techniques, information, 'tricks of the trade.' Speed of tapping, a function simple and presumably little affected by practice, was selected for the study. Eighty-two kindergarten children were divided into two comparable groups on the basis of 18 days' practice in tapping, chronological age, mental age, sex, and general motor ability as measured by teacher's judgments, and eight

motor tests. The practice group was given six months of daily tapping practice, or 76 trials in all. The control group had no practice during this period. All of the subjects had a 17-day final practice period. After six months of non-practice, both groups were retested. The practice group in all totaled 111 days of tapping; the control group, 35. Both groups showed rapid improvement during the initial period of practice. The practice group gave evidence of slow but steady improvement to the end. The control group after six months of non-practice was inferior to the practice group, but showed a gain over its last tapping score. In 11 days, the controls caught up with the practice group and remained practically equal in achievement to the end of the 17 days of the final practice period. Six months later, both groups were about equal. The authors make this conclusion:

"The fact that the practice group was no better after six months of continuous practice than the control group after a few days of readjustment . . . suggests that the improvement was due to technique and that even prolonged training had no perceptible influence upon capacity. . . . The fact that, after six months of disuse, the intensively trained practice group showed no superiority over the control group, points to the same conclusion" (17, p. 452).

In evaluating this experiment, it must be pointed out that a very simple skill was selected and that preliminary practice was given to all subjects until the stage of rapid improvement was passed. It seems likely that the children were approaching their physiological limit, and that intensive practice beyond this point was not of any permanent advantage. Quite

possibly, increased muscular coordination and growth in strength rather than training brought about the slight increase in tapping ability for both groups since the time element was uniform for all subjects. Furthermore, the control group continued to improve during the six-months non-practice period. This would seem to indicate that factors other than specific practice were influencing the learning process.

Auditory memory for digits (17) was studied by the same technique as tapping. Starting with an equal initial score, the practice group at the end of 78 days showed a gain of 2.07 digits, whereas the control group with no practice gained .73. Since no measures of dispersion are given, it is impossible to determine how significant this difference may be. On retest, however, four and a half months later, the advantage of the practice group was lost and the two were found to be about equal. The conclusion here as in the earlier study is that continued practice failed to give any fundamental advantage; there was, seemingly, no permanent increase in capacity. In both of these studies the authors have attempted to measure simple fundamental capacities that are little affected by training. Would the result have been the same if more complex skills dependent upon the combining of simple habits had been selected?

Two studies from Gesell's laboratory at Yale (21, 85) deal directly with the factor of maturation in learning. The method is that known as co-twin control, wherein identical twins, identity having been established by close mental, physical, and behavior cor-

respondence, were used. At 46 weeks of age, one twin was given six weeks of daily practice in stair climbing and cube piling; the other twin served as control. At the end of the training period, cube behavior was strikingly similar for both twins; no advantage resulted from the specific training. The trained twin, however, surpassed her sister in stair climbing at the end of the six-weeks practice period. At this point the control twin was given two weeks of stair-climbing practice, during which time she caught up with her sister. Evidence here indicates that the greater maturity of the control twin considerably offset her lack of training since two weeks' practice brought her to as high a state of proficiency in stair climbing as her sister who had training at an earlier age.

Later these same twins served as subjects for a language investigation. At the age of 84 weeks, Twin T was given five weeks of language and vocabulary training while Twin C was kept in a non-language but otherwise identical environment. Beginning at 89 weeks, Twin C was given similar language training. She learned more rapidly than her sister and at the end of four weeks equalled Twin T's performance based upon five weeks of training. Three months later, the two children were of about equal ability. Strayer notes that there were similar well-defined stages of development in both twins regardless of differences in time of appearance. Though the evidence here is not so clear as in the case of stair climbing and block piling, it favors the importance of maturation in the development of language, a function that of

necessity is acquired through environmental stimulation. Strayer concludes that "maturation influences not only effectiveness of training in vocabulary, but the general pattern of behavior. Training, although it cannot transcend maturation level, is to some degree effective in increasing vocabulary" (85, p. 312). From these two studies it seems that intrinsic and extrinsic factors of development may vary in different skills since maturation stands out more clearly as being effective in learning to climb stairs than in learning to talk.

A recent study at the Iowa Child Welfare Research Station (30, 31) is concerned with the relative influence of specific practice and maturation or general practice in a given motor skill (throwing at a moving target). Sixty children, between the ages of three and seven, were divided into two groups comparable in age, sex, and initial ability on the moving target. Three other motor tests were also given at this time. The practice group had eight weekly periods of ten throws, each followed by two tests. The controls rested during the eight weeks of practice but were given the two end tests. This made a total of 30 throws for the controls and 110 for the practiced subjects. Both groups made small gains from initial to end tests. The average gain for the practice group was 1.9; for the controls, 1.3, leaving a difference of .6, which was too small to be considered statistically significant. This study gives evidence that improvement in skill came, not so much as the result of specific practice, as from such factors as maturation and general practice. In repetition of

the three motor tests, controls proved to be as skillful as the practice group. Both groups made gains in arm strength and perforation tests comparable to their improvement in the moving-target ability, and both groups showed loss in the tracing test.

Related Learning Studies. There is evidence that the influence of specific practice varies with different skills. Gates' study shows no permanent advantage for the practice group in the simple skill of speed of tapping; however, we know from practical experience that training is necessary to perfect such complex skills as typewriting and golf. The work on stair climbing and language development of identical twins indicates that training and maturation are not contributing equally in both skills. It is possible that level of difficulty of task may be an important factor here. Two studies dealing with the factor of complexity or difficulty of task in relation to learning have a direct bearing upon this investigation. Ruch (78) selected tasks representing three levels of complexity and found in a group of 14-year-old children that the relation between mental age as represented by Army Alpha scores and achievement increased as one progressed from card sorting, through code substitution, to abstract relations. In card sorting, the relationship between mental age and performance decreased markedly with practice; in code substitution the decrease was slight, and in abstract relations, practice slightly increased the relationship. Ruch points out that one cannot generalize as to the form of the learning curve for different functions or different degrees of complexity. As a result of prac-

tice, individual differences increase in abstract relations; run parallel in code substitution; and decrease in card sorting.

Atkinson (1), investigating learning in card sorting, and number and alphabet substitution among college students, found that intelligence tests were a poor measure of performance in simple tasks as card sorting, but that they were more closely related to the more complex tasks of substitution. These two studies, somewhat similar in technique, support each other in showing that complexity of the task is a factor in the relationship between intelligence and performance. Their weakness lies in the fact that very different types of learning have been selected and labeled as simple or complex without any good objective criterion.

In a study of the relation of brain injuries to maze learning and relearning in rats, Lashley (54) finds supporting evidence for the theory that complexity of task is closely associated with degree of inferiority of the operated as compared with the normal rats. Operated rats required 3 times as much practice for learning the simple maze patterns as normal rats; almost 5 times as much practice for the pattern of intermediate complexity, and nearly 10 times as much practice for the most complex pattern. The author concludes that "the simple problem offers difficulties which are not much greater for the animals with brain lesions than for normal ones. . . . The more complex problem, on the other hand, is more difficult for animals with lesions than for normals" (54, p. 74). This same tendency seems to hold for tasks of different degrees of complexity in

brightness discrimination. Where the problem is that of discriminating between light and darkness, there is no retardation for the operated animals; where a second light was introduced and the animals required to choose the brighter of the two, there is marked superiority for the normal animals.

These studies raise the perplexing question of what constitutes complexity. By what criterion may we judge whether abstract relations are more complex than card sorting? Can we be sure that a maze pattern consisting of eight culs-de-sac is actually more complex than one of three? Lashley (55) suggests that complexity may be obtained by increasing the number of similar elements in a situation, or by changing, qualitatively, the relationship between them. Hollingworth and Cobb (33) define complexity in terms of number of associations involved in a task. Experimental evidence to support these theories is lacking. There is need for careful definition of the term 'level of complexity' in each study to avoid ambiguity of meaning. It seems as if complexity and difficulty were closely related, especially in a motor learning situation where accomplishment is measured in terms of time and error scores. One would assume that difficulty increases with increasing complexity of task, and hence that the number of errors, or length of time required for a given level of performance, would be, to some degree, a measure of level of complexity. However, this would follow only where tasks are similar in other respects; for example, equal distance in the true path of a maze pattern, or where different tasks are arranged

in a single series such as patterns on a particular type of maze, or different arrangement of lights in a visual discrimination box. We all recognize gross differences in complexity but there seems to be no basis for comparing degrees of complexity in two non-similar activities. It seems probable that an accepted criterion of what is meant by complexity would clear up the seeming inconsistencies in some of the learning studies.

Maze Studies. Since the purpose of this study was to investigate learning in relation to complexity of task, it was necessary to select some skill wherein tasks could be arranged in a single series from simple to complex. The maze seemed a suitable learning situation because patterns differing in level of complexity could be set up. The maze also has the advantage of being well adapted for work with preschool subjects since it can be made interesting, is not too difficult, and favors a trial-and-error method of approach.

The maze or labyrinth, which was first used for amusement and entertainment of adults, was taken into the psychological laboratory in 1896 by Thorndike. Early maze experimentation was with animals and not until 1912 was the enclosure type of maze adapted to humans (9). Perkins (70) reviewed maze literature and classified human experimentation into the following stages: early work to determine whether subjects could learn the problem; criticisms of learning curves and methods of recording; problems of transfer, mechanical guidance, and interference; and theories of motor learning and various factors that influence it. To this last type belongs the present study. Miles and

Knott (65), in a history of maze studies, give four types of mazes: the enclosure, made up of pathways through which the subject travels; the maze in miniature which may be explored by stylus, pencil, or, as in this study, by a rolling ball; the mental maze; and the elevated finger maze. A chronological outline by McGinnis (63), in 1929, lists 40 maze experiments upon human subjects. It is interesting to note that only four of them include the preschool age.

Criteria of Maze Learning. The question of what constitutes the best criterion of maze learning is one that has received a good deal of attention. Maupin (59), in a review of literature on habit formation in animals, discusses this subject. Yerkes (103), in experiments with the dancing mouse, discards time as an invalid measure of maze learning because of the many interrupting factors which may enter in. He speaks of the rat stopping to wash its face, looking around, or being hurried by shock into an error. For this reason he would give errors first place, and consider time as of only secondary importance. Watson (96), in 1914, says that time, carefully controlled, is the only safe guide to estimating the learning process of a maze. Hicks (32), 1911, prefers the distance curve. She points out the difficulty and impracticability of getting it and substitutes time as perhaps the best single criterion of the learning process. Watson's later invention of the Johns Hopkins circular maze with camera lucida attachment, which makes possible the accurate record of distance, would do away with Hick's objection to distance. Vincent, 1915, finds curves for error

and time dissimilar. Trials, according to Brockbank (3), 1919, give a better measure than either time or distance because learning consists in the establishment of integrations of movements, the loss of which would be indicated by the need of a greater number of trials after a period of disuse. Both time and errors are used by Davis and Tolman (14), 1924. In 1930, Liggett (56) raised the question of the best measure of maze learning. The advantage of time, he points out, is that it is easy to get and leaves the experimenter free for other recording. Time may be either total or static, which represents the amount of time not spent in actual maze travel. The last is difficult to get because there is no satisfactory criterion as to what constitutes a stop. By subtracting static from total time a running score is obtained, or the time actually spent in maze travel. Running time would meet Yerkes' criticism because from it have been eliminated the interrupting activities. The chief difficulty in error score lies in determining a suitable criterion for error. Should merely entering a blind be counted as an error, or must the blind be completely traveled? Also the question of gradations of difficulty in errors comes up here. Total distance is a refined error score. Number of trials is not satisfactory because it does not show progress from trial to trial, and because it requires the setting of an arbitrary standard for perfect learning. Should complete learning consist of three or five successive perfect runs or some other number? Speed, according to Liggett, is the best single score. It is obtained by dividing total distance by total time. Liggett points out

that time, according to learning curves, seems to be principally a function of speed. Since error curves do not resemble speed they also should be reported in a maze study. Heron (28), 1922, using the Watson circular maze, recorded net time, obtained by subtracting static from total time, and surplus distance, which is the difference between a perfect run and the actual distance traversed. He questions speed because it is apt to be related to different physiological levels of functioning. Cox (12), 1928, found general agreement between time and error scores on a two-story duplicate maze. This last study is the only one here referred to in which human subjects were used.

With such disagreement between workers in the field, it is difficult to select any one criterion as valid for maze learning. The safer method is to obtain as many different measures of learning as possible and, in interpreting the data, to bear in mind the limitations of each.

Reliability of the Maze. Most of the work on reliability of the maze has been done in the field of animal learning. In 1922, Heron (28) pointed out that previous workers had not been concerned with the reliability of their instruments and emphasized its importance in evaluating the results of any learning problem. He attempted to determine the reliability of the Johns Hopkins circular maze by correlating it with the problem box and found all correlations low. Hunter, working contemporaneously in the same laboratory, found a high degree of reliability between ability to form a simple maze habit and to break it by forming another

in human subjects, but low reliability in rats. He suggests that this difference may be due to better methods and more uniform control for humans. Davis and Tolman (14) in 1924 reported odd-even coefficients for eight days of learning in rats on two types of mazes of .44 and .04 for errors, and .21 and .32 for time. Hunter, the same year, made this statement:

"No maze, either for rats or humans, is analyzed sufficiently to justify the unqualified acceptance of data gathered from it with reference to the determination of individual and group differences in learning. Habit formation does take place in the maze, and most subjects can be trained to a point of mastery; but a comparison of subjects upon the basis of data gathered on the learning process itself is of very uncertain value" (39, p. 440).

He reports 470 correlations, ranging from $-.33$ to $.85$, with an average of $.30$. Carr (8), in 1926, replied to Hunter that no one was proposing to use maze records of learning for individual comparisons, but that it was suitable for group study to determine the effect of changing conditions upon maze learning ability. Tryon (92), the same year, published an article stating the thesis that, instead of invalidating results, the effect of unreliability of instrument is to make an obtained difference more significant.

This controversy over reliability of the maze has led to emphasis upon more careful experimental control and to work with different types of mazes. As early as 1912, Carr (9), in criticizing trials as a measure of maze learning because they were so dissimilar, suggested that the difficulty was partly that of non-comparable apparatus and technique. He advocated a

standardized maze. Hunter (40), in 1926, in his reply to Carr, states that in the Kansas studies the maze did not give satisfactory reliability, but he believes careful attention to precision of methods would greatly help. He cites the fact that reliability is greater for humans than animals and that this is probably due to the influence of verbal instructions.

Recent maze studies have yielded higher reliabilities than earlier ones. Stone and Nyswander (84), in 1927, using a multiple-T maze, report coefficients ranging from .49 to .99. Similar reliability coefficients were obtained by Burlingame and Stone (5) in 1928, and by Heron (27) in 1930. These three studies of rat learning determined reliability according to four methods: sum of the errors on the odd days correlated with the sum of the errors on the even days; sum of the errors on the odd blinds correlated with the sum of the errors on the even blinds; sum of the errors on the first half correlated with the sum of the errors on the second half of the maze; and the sum of errors for any segment correlated with the sum of errors for any other segment.

In the field of human maze learning, high reliability coefficients are being obtained. Husband (42), in 1929, in a comparative study, found reliability coefficients of .93 and .96 for humans. They were somewhat lower for rats, .80 and .86. Knotts and Miles (50), in 1929, reported reliability coefficients for blind children, using finger and stylus mazes, from .88 to .98. McGinnis (63), in 1929, on the Young slot maze, with preschool subjects obtained coefficients ranging

from .83 to .98, and on a non-visual cue stylus maze, .33 to .66. Nyswander (67), in 1929, pointed out that reliability is affected, not only by factors of maze construction such as pattern and number of blinds, but also by complexity; and that neither a very simple nor a very complex maze satisfactorily differentiates among individuals. Her coefficients on a high-relief finger maze run from .56 to .79. Peterson and Allison (74), in 1930, found a relationship between the magnitude of reliability coefficients and amount of visual exposure. Their work, which yielded reliabilities from .48 to .87, suggests that one can increase reliability on a human stylus maze by visual exposure before each trial. Spence and Townsend (83), in 1930, with two groups of high and low intelligence on a Miles high-relief finger maze, found reliability coefficients ranging from .93 to .98, and concluded that the maze is highly reliable for group differences.

Summary of the Literature. In summarizing the experimental literature related to our problem, there are three main types of investigations: those attempting to separate the influence of specific practice provided by the environment; studies dealing with degree of complexity of task, and the learning process; and related maze studies. Evidence tends to support the theory that factors other than specific practice are responsible for learning. In such skills as speed of tapping, memory for digits, and hitting a moving target, controls did about as well as practice subjects. In cube piling, stair climbing, and, to a lesser degree, language acquisition, maturation seems to overshadow the effects of training.

Two studies, based upon such skills as card sorting, substitution, and abstract relations, point to complexity of task as a factor in the relationship of intelligence to performance. Work on rats with brain lesions indicates an increasing retardation of maze performance with increasing complexity of pattern. Does level of complexity in a skill bear relationship to the effectiveness of practice or retention in learning?

The phases of maze learning which most concern this study are: ascertaining what is the best criterion of learning; and determining whether the maze is a sufficiently reliable instrument for measuring group differences. The measures of maze learning most frequently reported are time, errors, and number of trials, but some experimenters prefer the more refined speed and distance records. There is considerable difference of opinion as to which measure best represents the changes actually taking place. Early maze studies yielded low reliability, but more recent work has proved the maze to be as reliable as other motor skills and tests. In the field of human learning, maze reliability coefficients run from .80 to .98; well above the standard set by Kelley as necessary for distinguishing between group differences. We may say that the maze is a suitable instrument for attacking the problem of learning.

II

PROCEDURE

PURPOSE

The purpose of this study is to determine for a given motor skill, performance on the rolling-ball maze, whether degree of complexity of task bears any relationship to level of functioning attained through practice. Experimental work has shown for certain skills that growth and development may bring as high a degree of proficiency as specific practice. Is this true of learning on the rolling-ball maze? Will practiced subjects have greater advantage over unpracticed subjects in complex tasks than in simple ones? It is also hoped that such a study will give further understanding of the process of learning in this type of motor skill.

THE LEARNING SITUATION

Certain requirements were kept in mind in selecting the learning situation to be used as the basis of this experiment. The first was that it be a skill which, in general, would lend itself to a trial-and-error method of attack, as there should be a gradual elimination of errors or increase in ability rather than sudden complete solution. This is an essential element in a study where practice is being given in equal time units and achievement in tasks of different levels of difficulty is being compared. Secondly, it should have within it different degrees of difficulty, or complexity, for practice is to be studied in relation to complexity of the task. It is hard to say just what elements make one

task more difficult than another; in many instances we lack suitable criteria for defining complexity, yet we do recognize gross differences in the two extremes of a given skill. That is all we aim to do here. For the purpose of this study, that task is considered to be more difficult, or more complex, which requires more time to complete and which involves the greater number of errors. Since the tasks employed are steps in a single motor skill, this problem of what constitutes complexity is thus considerably simplified. Thirdly, it should be novel so that the subjects will be relatively unpracticed at the beginning of the study and will have no opportunity for additional practice during the experiment. A learning situation made up of common play materials or everyday skills which are developing independent of the experimental situation, or one to which some children have greater access than others, would tend to cover up the effects of practice within the experiment and so make results difficult of interpretation. Fourthly, the learning situation should be suited to the age and ability of the subjects. This means that the task be neither too easy nor too difficult for the particular group of subjects and also that it differentiate between them. Preschool children were selected for this study because they are of an age when growth is going on rapidly and when many skills are being acquired. A fifth requirement is that the learning be rapid so that one can get measurable improvement in a relatively short time. Lastly, the skill should be interesting to young children. This involves the very important factor of motivation. Where the learn-

ing process covers an extended period of time boredom and lack of cooperation on the part of the subjects may seriously affect the rate of learning. Outside incentives may be used, but these are never as satisfactory as a learning situation which itself holds the interest of the subjects.

DESCRIPTION OF THE APPARATUS

After searching about for a type of learning situation that would best meet the above requirements, a rolling-ball maze was constructed. It is built somewhat upon the plan of the Carr stylus maze (9) that was used in a study of the effect of visual guidance. Here, however, instead of tracing the path with a stylus, a ball is rolled over the path to the goal.

The maze was made of a metal plate 9 inches square and of sufficient thickness to be tapped for machine screw threads. The outline of a $7\frac{3}{4}$ -inch square was made in the center of this plate. The inside of the square was marked off into 81 smaller squares of equal size. At the intersection of each pair of lines making up this checker-board effect, a hole was drilled and tapped for a machine screw, size 10-32, there being 100 such holes; one at the intersection of each cross and border line. Into each of these holes was screwed a 10-32 round-head machine screw to the depth of approximately $\frac{7}{16}$ of an inch. A nut of the same size was screwed on the exposed end and was tightened down against the plate to act as a lock nut.

The spacing of these screws was $\frac{7}{8}$ of an inch from center to center, leaving an actual clearance between

the inside edges of the screws of about $11/16$ of an inch. These spaces between the rows of the screws formed a track for the $5/8$ -inch steel ball used in the maze. The actual pattern of the path which the ball was allowed to take was made by adjusting the screws for height so that they either obstructed or cleared the passage of the ball. The difference in height of the 100 screws for any given pattern was not great enough to indicate the true path and positions of the culs-de-sac when the maze was held in the two hands in working position. The ball was set in motion by tilting the maze in one of four directions: to the left, right, towards, or away, from the body.

The metal plate which made up the maze was set in a narrow frame of wooden picture molding. The metal used for this maze was sheet aluminum, selected because of its resistance to tarnish and the ease with which it could be machined. It was found that the steel ball had a tendency to leave a slightly discernible trace of its path after constant use. A suggestion is therefore made that a harder metal, such as brass, stainless steel, or even ordinary steel, which, however, would have to be watched for rust, would be better material for the maze. However, it was possible to scrub off the evidences of the track left by the rolling ball from the aluminum by the use of fine abrasive material. To facilitate experimental procedure, three separate mazes were constructed and a different pattern set in each one. These were identical in appearance so that the subject could not tell by looking at the maze upon which pattern he was working.

Mechanical Device for Recording Errors. Since the ball was set in motion and made to follow the path by tilting the maze in different directions, it was possible to determine the fewest tilts in each direction which were necessary to direct the travel of the ball over the true path. Any tilt over and above this minimum number would constitute an error in direction of movement because it indicates that either the subject does not know the correct path, or that he lacks control in directing the ball over the route. Learning would tend to eliminate both of these types of error.

A mechanical device was therefore constructed which would hold the maze, limit the degree of tilting, and record the number of motions in each direction used in the maze solution. This apparatus consisted of a metal tray just large enough to hold the maze. To the bottom of the tray at its center point was attached a universal joint set upon a pedestal which elevated the tray 6 inches above a wooden base and allowed it to tilt in any direction. Below each corner of the tray, a metal post, $5\frac{1}{2}$ inches in height, was fastened to the wooden base. These four posts limited the amount of tilting of the tray to $\frac{1}{2}$ inch, an amount sufficient to allow for the operation of the maze.

The following system was worked out for mechanical counting. Between each pair of corner posts and affixed to the wooden base was placed a Veeder single-action arm counter. The arm of each counter was attached to a point above it on the tray by means of a spring. The spring was so adjusted as to give positive

action with the counter and still allow flexible connection with the arm of the counter. When the four counters were connected in this manner, any tilting motion of the tray carried to a point where it was stopped by the posts would be recorded by one or another of the counters.

Continued experimentation with the counters used in this device failed to give accurate record of the tilting motion unless the movement was sufficient to bring the edge of the tray in contact with the two appropriate corner posts. Tilts of slighter magnitude, while great enough to set the ball in motion, would not always be recorded by the counters. To make sure that the tilt would be great enough to be accurately recorded by the counters, the metal posts were electrically wired in such a manner that when the metal tray made contact with any two posts, electrical contact was formed which sounded a buzzer. The rule was laid down that, in working the maze, each tilt should be great enough to make the buzzer sound, thus insuring accurate recording by the counters.

Recording of Maze Performance. In the main experiment, time and error records were obtained for each trial; a trial consisting of a successful maze performance where the ball reached the goal. Time was measured by a stop-watch in fifths of a second from the moment the ball began to move until it came to a stop in the lower right-hand corner of the maze. Counter readings for the four different directions of movement were recorded on uniform blanks for every individual at the beginning of each day and after each

maze trial. By subtracting the second reading from the preceding one, a movement score was obtained for every maze trial in each of the four directions. The sum of these constituted the total movement score for a single trial. To get an error score, the appropriate number, 5, 12, or 19, was subtracted from the movement score on the respective maze pattern I, II, or III. These numbers represented the fewest possible movements required to direct the ball over the true path of the maze; any movement above the designated number constituted an error.

Maze Patterns. The set-up of the experiment required three maze patterns of different levels of complexity. Complexity is here defined as that quality which makes for a greater expenditure of time and a greater number of errors in maze learning. Since there was no accurate way of determining in advance just how difficult a given pattern would be for a group, trial-and-error method was resorted to. It seemed reasonable to assume that factors influencing the degree of complexity would be the number of turns in the path, position, and direction of turns, length of path, and the number and position of culs-de-sac. With these in mind, three patterns were set up and tried out on a small number of subjects. Adults were used in this preliminary work because they were more available and easier to work with than children. After considerable experimentation with different patterns, some 12 or 15 in all, a set of three was worked out that seemed to give clear-cut spacing with respect to complexity or difficulty of task. Table 1 gives the

TABLE 1
MEAN TIME SCORES OF ADULTS FOR MAZE PATTERNS DIFFERING
IN COMPLEXITY

Pattern	Mean (seconds)	Range (seconds)
Simple I	17.75±8.95	6 to 41
Intermediate II	26.54±17.38	16 to 76
Complex III	64.67±25.98	30 to 110

TABLE 2
MEAN TIME SCORES OF CHILDREN FOR MAZE PATTERNS
DIFFERING IN COMPLEXITY

	Pattern I	Pattern II	Pattern III
Errors	2.11±1.30	10.88±21.87	19.95±4.49
Time	17.82±2.56	47.84±8.11	85.16±4.52

mean time scores for a group of 12 adults having three trials for each pattern.

Hereafter Pattern I will refer to the simplest, Pattern II to the intermediate, and Pattern III to the most complex task. Mean scores for the first four days (12 trials) of the main experiment on a group of 50 children show relatively the same spacing of complexity reported for adults (see Table 2).

It is true that occasionally individual learning curves cross for the different patterns, but there is no crossing in the composite group curves. The three patterns stand out as separate and distinct. We can therefore say that these are three patterns, differing in levels of complexity, but can make no assumptions as to the exact degrees of difference between them.

In order to keep the three patterns as nearly comparable as possible, certain conditions were kept uniform. The true path of the maze is always the same

distance, 30 units, a unit being the distance between two screws. In each case the true path starts in the upper left-hand corner and ends in the lower right corner of the maze. All culs-de-sac are of equal length, 1 unit. There are no forward-going culs-de-sac. Since the pattern is concealed, it was possible to make the three maze patterns identical as far as appearance was concerned. The subject could not tell by looking at them which pattern was the most difficult and which the easiest. A small numeral on the under side served to identify them for the experimenter. This identity of appearance and the fact that visual cues have, so far as possible, been eliminated in the rolling-ball maze, made possible full use of vision in maze learning. Carr's (7) work in 1921 indicates that by this method we have probably speeded up the learning process, since he found a positive relation between the amounts of visual inspection and reduction of errors on a stylus maze where stops were invisible. Peterson and Allison (74), in 1930, found that visual exposure increased reliability in a stylus maze. The chief advantage of normal use of vision in this study lies in the fact that it tends to keep the experimental situation more natural. Little children, as a rule, object to the hampering of their vision, and, under those conditions, it is difficult to get complete cooperation.

Figure 1 shows the three maze patterns used in this experiment, representing the three levels of difficulty of performance. Pattern I has no culs-de-sac, and requires a minimum of 5 movements to send the ball over the true path. Pattern II has three culs-de-sac; one

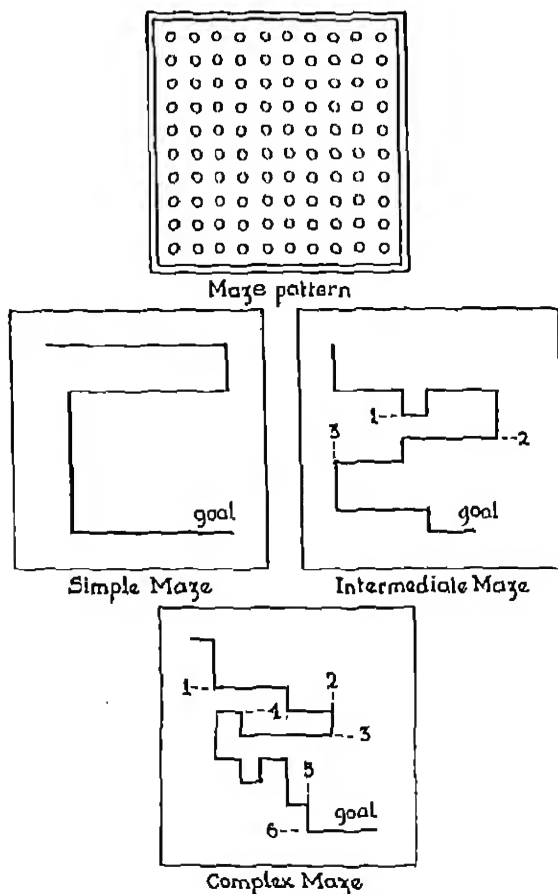


FIGURE 1

CHILD'S VIEW OF THE MAZE AND DIAGRAMS SHOWING THE
THREE PATTERNS

to the right, one to the left, and one away from the subject. It requires 12 movements to complete the true path. Pattern III has six culs-de-sac; two to the right, two to the left, and two away from the subject.

At least 19 movements are necessary to travel the pattern correctly.

Directions for Maze Operation. The maze with Pattern I in position is placed on a low table, 21 inches high. The child and experimenter stand directly in front of the maze. The child has been previously invited to come and play a marble game. The experimenter says, "*This is a game where we make the bell ring. When I press it down this way the bell rings, and when I press it down this way the bell rings, and this way, and this way.*" The experimenter illustrates by tilting the maze once in each direction, causing the buzzer to sound each time. "*Now put your hands here like mine and see if you can do it too.*" The experimenter illustrates again in a similar way, holding her hands over the child's and helping him. "*You have to press it way down and be sure that the bell rings each time.*" The child goes completely around two times, pressing the maze in each direction twice. The ball is shown to the child. "*There is a marble in this game. When you ring the bell you make it go too.*" The experimenter puts the ball in the lower right-hand square (the goal). "*See, when I press it down this way the marble goes, and this way, and this way.*" The experimenter tilts the maze to the left, causing the ball to travel in that direction as far as it can go; to the right, and back to the left again. "*Now it goes this way and back again.*" The experimenter rolls the ball away from, and towards her. The ball is returned to the goal and the child given a turn to repeat these movements. If he has difficulty, the

experimenter helps him, and this is continued until the child can easily direct the ball in the four directions. The experimenter sits beside the table at a point where she can easily read the counters, and gives the ball to the child saying, "*You hold the marble while I write down some numbers and then we will play.*" When the counter numbers have been recorded on the child's record blank, the experimenter points to the goal at the lower right-hand square, saying, "*This is the house where the marble lives, and this is where we put it,*" (putting the ball at the starting-point in the upper left-hand corner). "*Do you think that you can find the path right down to the little house? Press very hard every time so that the bell rings, and if the gate is shut, and the marble can't go any farther, try another way. Now begin.*" The first trial of each of the patterns is considered an adjustment series. The experimenter insists that the bell be rung each time, and, if necessary, helps the child press the maze down so that it comes in contact with the metal posts. The following instructions are repeated when needed: "*Keep the ball moving all the time until it finds its house. Let the ball go as far as it can. Try every way until you find the open gate. This* (pointing to the goal) *is the house where the ball has to go.*"

During the experiment, the three maze patterns were placed at the back of the table in order of complexity, from left to right. As a particular pattern was needed, it was placed in the maze and later returned to its former position. Children helped with this process. Those who knew numbers were encouraged

to help read the counters for recording movement scores. All children seemed interested in the stopwatch and were allowed to press the stem after recording, to watch the second hand spring back into place. Some few could read the seconds, and these seemed interested in finding out whether a turn took longer than the one before. This factor may have stressed time in the minds of the children, and made it more important to them than elimination of errors. However, many of them never seemed to get the idea that a diminishing time score indicated better performance for they would say, "Look how long it took me. I did pretty well that time."

After Pattern I was completed, Pattern II was placed in the maze, and the following instructions were given. *"There is a different path here. See if you can find it as you did before, and make the ball go way down to its little house."* Similar instructions were given for Pattern III. After the first trial with each pattern, the experimenter simply said, *"Now make the ball go to its house."*

PRELIMINARY STUDY

A preliminary study was undertaken to determine whether available criteria other than performance on the rolling-ball maze itself could be used for dividing the subjects into two nearly identical groups who, under uniform conditions of practice, would progress in maze learning at about the same rate. It was highly desirable that the subjects be paired upon some outside criterion. In that event one group would be given considerable practice, the other group no prac-

tice upon the rolling-ball maze and differences in performance could be more definitely attributed as due to the effects of practice. If, however, all subjects have had some maze experience previous to pairing, the effect of later practice might be hidden by the relatively greater effectiveness of the first few trials, and results would then be difficult to interpret.

The apparatus used in this preliminary study was a simpler form of the rolling-ball maze that was held in the hands. With this type of apparatus, time was the only measure of learning. Twenty-eight kindergarten children participated in this preliminary study, 16 boys and 12 girls. Three trials were given daily upon each of the maze patterns in the following order: Patterns I, II, III, II, III, I, III, I, II. For all subjects the learning period was composed of eight practice days.

Three other measures were obtained on these children for the purpose of correlation with maze performance: scores on a tapping test that had been used by Goodenough and Tinker (24); time scores on a wooden rolling-ball maze of different pattern so constructed that the entire pattern was visible; and IQ's obtained on the Minnesota Preschool Test.

Subjects were paired six different times upon the following criteria: first day of maze practice, 3 trials; first two days of maze practice, 6 trials; intelligence test scores; speed of tapping; wooden maze performance; and a composite pairing on the basis of chronological age, sex, tapping, and first three trials. Percentage of gain was used as the measure of learning.

TABLE 3
PRELIMINARY STUDY
CORRELATION OF PERCENTAGE GAIN IN MAZE ABILITY BETWEEN
TWO ARRAYS OF SUBJECTS PAIRED UPON FIVE
DIFFERENT CRITERIA
N=28

Criterion for pairing	rho	
1. Initial status (first day or 3 trials)	.24	±.17
2. Initial status (two days or 6 trials)	.63	±.10
3. Intelligence quotient	-.04	±.18
4. Tapping speed	.17	±.18
5. Wooden maze (6 trials)	-.30	±.19
6. Composite (CA, sex, tapping, 3 maze trials)	.46	±.15
Paired according to chance	.40	
	-.36	
	-.06	
	.21	
Mean - - - - -	.19	

In each case percentage of gain of one of the two partners was correlated with percentage of gain of the other partner. Since the entire group included but 14 pairs, the Spearman rank-order correlation method was used.

Table 3 shows all coefficients low with the exception of that based upon two days' maze learning. With the exception of performance on the maze itself, no single pairing criterion gives even reasonably high relationship. The composite gives a somewhat larger coefficient than the simple criteria, but even this is not within the limits required for statistical significance. It would seem from these data that the only satisfactory criterion for pairing into two comparable groups of maze ability is preliminary practice upon the maze itself. This would require not less than two days or six trials. Since correlation upon

that basis was only .68, a longer period would probably be better.

An attempt was made to determine what would be the relation between percentage of gain of two partners if they were paired upon pure chance. Four different chance pairings were made by shuffling the children's names and drawing them from a hat. As will be seen in the table above, the average coefficient was .19, about the magnitude of the other coefficients presented in Table 3. Hence pairing on any of the outside criteria or even upon a very short practice period on the maze itself has little advantage over chance. This would suggest that ability on the maze used in this experiment is specific and not closely related to other measures here considered. As a result of this preliminary investigation, it was decided to give all subjects four days' practice upon the specific patterns to be used as the basis for pairing into experimental and control groups.

THE MAIN EXPERIMENT

Description of Subjects. Fifty children, ranging in age at the beginning of the experiment from 4 years and 10 months to 6 years, served as subjects. They were drawn for the most part from the kindergarten of the Institute of Child Welfare, University of Minnesota. Additional children came from Northeast Neighborhood House, Washington Neighborhood House, and Hawthorne Kindergarten, a Minneapolis public school. Chronological age was determined to the nearest half month at the date of first trial of maze

TABLE 4
DESCRIPTORS OF SUBJECTS—24 BOYS AND 26 GIRLS

	Mean	S.D.	Range
Chronological age	64.70 mos.	3.82	72- 59 mos.
Intelligence quotient	103.40	6.36	85-121

learning. Intelligence quotients were based upon the Minnesota Preschool Scale. The children in the University Kindergarten had taken these as a part of their regular school routine. The other children were tested by a trained mental tester. The one exception was a child in the control group whose Detroit Kindergarten Test record was converted into an intelligence quotient. Table 4 gives the means and standard deviations for the entire group of subjects.

Pairing. The preliminary experiment indicated that no one of the outside criteria or even a somewhat similar maze with visible pattern would satisfactorily divide the subjects into two groups of comparable ability on the rolling-ball maze. Heron (28) found with adults, using five different patterns of a stylus maze, that there was only a slight relationship between individuals' scores on the five patterns. It seems that maze ability is not a general function but must be specifically determined for any given type of maze, and for each different pattern. In view of this, it seemed best to use all three patterns as a basis for pairing into experimental and control groups.

The next question concerned itself with determining how many trials would be required to give a reliable measure of initial maze ability. Since, for purposes of comparison, the control group was to have a minimum

of maze experience, it was desirable to make this pairing series as short as possible. Maze records of the first few days of practice were available for nine children. A Spearman rank-order correlation was computed, using the first four days for the three patterns combined, with coefficients of $.93 \pm .03$ for time and $.93 \pm .03$ for errors. Very little dependence can be placed on these coefficients since they are based upon so few subjects, but they seemed to indicate that four days of maze learning would be sufficient to give a fairly reliable measure of initial maze ability for the purpose of group comparisons. Table 5 gives coefficients for the larger group of 50 children who were subjects for the main experiment.

Experimental and control groups were selected by matching two individuals for sex, chronological age, intelligence quotient, and maze ability. To determine maze ability, the sum of the average scores for the first four days on each of the three patterns was found. This was worked out for both time and movement, and the two sums added together, giving a composite score. Such a combination of time and movement scores would tend to overweight time because of its greater

TABLE 5
ODD-EVEN CORRELATION COEFFICIENTS FOR THE FIRST FOUR
DAYS OF MAZE LEARNING

Pattern	N	Time		S.-B. ^a	Errors		S.-B.
		r	P.E.		r	P.E.	
I	50	.55	.06	.71	.67	.05	.81
II	50	.69	.05	.81	.49	.07	.66
III	50	.74	.04	.81	.58	.06	.73

^aS.-B.—raised by the Spearman-Brown prophecy formula.

magnitude as compared with movement, and, for the same reason, the more complex patterns would receive more weight than the easy one. However, this seemed the best method available as it took into consideration both time and movement. Pairing had to be done upon the basis of a few children at a time as the experiment progressed. Limitations of time and availability of children made it impractical to work with

TABLE 6
PAIRING ACCORDING TO MAZE ABILITY

Subjects	M	Experimental			M	Control		
		T	MT	S		T	MT	S
1	308	586	894	251	265	544	809	348
2	246	521	767	358	253	547	800	328
3	255	480	740	352	260	450	710	362
4	323	683	1006	254	287	750	1037	264
5	283	567	850	301	316	534	851	299
6	298	623	920	271	257	637	894	313
7	262	537	799	336	247	524	771	348
8	293	614	907	287	265	678	942	272
9	291	793	1085	298	272	836	1109	238
10	289	604	893	297	255	664	918	309
11	248	540	788	348	275	557	831	317
12	242	577	820	339	293	516	810	311
13	269	501	771	337	251	518	769	333
14	268	535	803	318	249	511	760	344
15	326	681	1006	198	297	683	980	279
16	398	642	1020	140	264	704	968	280
17	258	543	802	324	239	595	834	309
18	271	546	817	319	286	561	847	301
19	338	630	968	245	276	643	969	287
20	269	629	898	309	303	581	884	254
21	285	669	954	250	269	688	957	259
22	263	569	832	322	302	536	838	287
23	263	511	775	343	252	536	788	331
24	222	511	733	378	249	495	744	359
25	268	611	879	298	268	589	856	301
Means	282.50	590.80	869.80	202.94	269.30	622.00	868.60	307.34
S.D.	37.23	69.86	92.04	52.49	19.13	90.60	95.01	34.64

M—sum of mean daily movement scores for Patterns I, II, III.

T—sum of mean daily time scores for Patterns I, II, III.

MT—sum of mean daily movement and time scores for Patterns I, II, III.

S—Sum of sigma scores on both movement and time for Patterns I, II, III.

more than 8 or 10 subjects on the same day. Experimental data were gathered over a period of 11 months; new children being added as others completed the practice series.

Table 6 shows how accurately individuals were paired according to several criteria of maze ability. It will be noted that means of control and experimental groups are approximately equal, but standard deviations vary considerably for the two groups. Sigma scores are probably the best measure of maze ability on the three patterns because, in determining them, individual scores are all reduced to standard deviations, and so the factor of overweighting high scores such as time as opposed to movement is eliminated. Table 7 shows how closely the individuals were matched according to chronological age, intelligence quotient, and occupational status of father.

Distribution of Practice. The general plan of the experiment was as follows. After an initial four-day period of practice for all subjects, two comparable groups were selected. Of these the experimental group was given an additional 26 days of maze practice while the control group had no practice. At the end of this 26 days of practice for the experimental group, all of the subjects were given an eight-day test of maze ability. Two months of non-practice followed for all subjects, terminated by a second eight-day test period which will be designated as the retest. Table 8 shows the approximate distribution of time and practice as planned for the subjects of the experiment.

Total days of practice for the experimental group

TABLE 7
PAIRING ACCORDING TO CHRONOLOGICAL AGE AND INTELLIGENCE
QUOTIENT

Pairs	Chronological age (mos.)		Intelligence quotient	
	Exp.	Con.	Exp.	Con.
1	71	65	92	101
2	69	71	112	108
3	69	67	112	109
4	62	64	107	110
5	69	71	113	114
6	63	59	120	121
7	63	62	110	121
8	70	72	96	108
9	63	63	104	96
10	61	60	97	105
11	67	69	109	112
12	70	67	116	102
13	65	66	110	111
14	60	59	96	103
15	61	61	85	94
16	63	60	100	117
17	68	65	98	88
18	61	61	119	110
19	62	66	90	100
20	61	59	121	107
21	58	61	85	98
22	61	67	88	100
23	69	65	110	112
24	64	65	103	110
25	71	69	92	89
Mean	64.84	64.56	102.68	104.12
S.D.	3.73	3.91	7.10	5.43

TABLE 8
DISTRIBUTION OF PRACTICE FOR SUBJECTS

Group	Initial	Practice	Test	Forgetting	Retest	Total practice
Experi- mental	4 days	26 days	8 days	60 days	8 days	46 days
Control	4 days	none	8 days	60 days	8 days	20 days

were 46; and for the control group, 20. Since each day included three trials on each of the three patterns, the experimental group had in all 414 maze trials; the control group, 180.

A fixed schedule of five practice days a week, omitting Saturdays and Sundays, was adhered to as closely as possible. In spite of great care, there were numerous irregularities caused by illness of the subjects, absence from school for other reasons, and school holidays. Table 9 gives the actual time intervals for the two groups.

The first 38 practice days included for the experimental groups: initial, 4 days; practice series, 26 days; and test, 8 days. For the controls there was a similar period of time divided as follows: initial, 4 days; non-practice series, 26 days; and test, 8 days.

Order of Presentation of Three Maze Patterns. The three maze patterns were used every day so that learning took place simultaneously on all three. In order to equate amount of practice, each pattern was presented three times during the daily practice in the following order: I, II, III, II, III, I, III, I, II. According to this arrangement, each pattern came once as first, once as second, and once as third in the series of

TABLE 9
COMPARISON OF TIME INTERVALS IN MAZE PRACTICE

	Experimental		Control	
	Mean number of days	S.D.	Mean number of days	S.D.
First 38 practice days	58.28	3.80	57.96	5.85
Forgetting interval	62.27	3.93	65.09	5.77
Retest	12.86	3.26	11.00	1.88

three. An exception to this order was the first day of maze practice. Because of the newness of the experimental situation, and the relatively greater difficulty at the beginning of maze learning, the first day included one trial in order of difficulty for each pattern; the second day completed the series with patterns in order of II, III, I, III, I, II. Thus the first two days from point of view of practice are equivalent to one day of the regular series and will be referred to as such in the presentation of results.

Experimental Conditions. Maze practice was given to each child individually in a separate room free from distracting influences or the presence of other persons. Conditions were kept as nearly constant as possible; the same room and set-up being used throughout, and the same experimenter supervising the practice. While conditions were kept uniform for a given group of subjects, they necessarily varied from group to group because the experiment was carried on simultaneously in different schools. Such influencing factors as the type of room, arrangement of furniture, height of table, and other external conditions were, to some extent, determined by the facilities available in the various institutions. The table upon which the maze was placed approximated 21 inches, a height which brought the maze at a convenient level for the standing child. Occasional home practices made necessary by extended absences from school for slight physical disturbances, or school vacations, also introduced variations in conditions of practice. The hour of day was kept fairly constant and was selected at a time which would in-

terfere as little as possible with the regular kindergarten program. This was between the hours of 9:00 and 10:30 for the morning group, and between 1:30 and 3:00 for the afternoon group. The data were gathered over a period of 11 months, beginning in August, 1930, and extending through June, 1931.

Motivation. Motivation did not seem to present a difficult problem. The rolling-ball maze appealed to the children and constituted the chief incentive. Children were encouraged to assist with the procedure, placing the maze patterns in the holder, and pressing the stop-watch after each turn. The experiment was given as a part of the regular school routine, and in most cases was unquestioningly accepted as such. Watching the filling up of the child's record blank served as a definite objective. Each day's record was written down and the remaining days of practice counted so that the child would have a feeling of progress, and would know how much more was expected of him. This procedure was especially effective towards the end of the practice period when some of the children began to show evidences of lagging interest.

Reliability. Reliability was computed for the subjects of this study upon the basis of time and error scores by correlating the sum of the odd days against the sum of the even days. The method is one suggested by Stone and Nyswander (84) for rat maze learning. Since the experimental and control groups were given different amounts of practice, reliability coefficients have been computed separately. They range from .62 to .97.

TABLE 10
CORRELATIONS OF SUMS OF ODD AND EVEN DAYS—PEARSONIAN r

Pattern	Time		Errors	
<i>Experimental group—No. 25, 38 days</i>				
I	.83±.03	.91*	.74±.04	.85*
II	.94±.02	.97*	.92±.01	.96*
III	.95±.02	.97*	.77±.04	.87*
<i>Control group—No. 25, 12 days</i>				
I	.97±.01	.99*	.68±.05	.80*
II	.82±.03	.90*	.75±.04	.86*
III	.89±.02	.94*	.62±.06	.77*

*Raised by Spearman-Brown prophecy formula.

TABLE 11
RELIABILITY COEFFICIENTS OF OTHER MOTOR SKILLS OF
PRESCHOOL CHILDREN

Date	Author	Skill	No. subjects	Reliability coeff.	
1926	Wellman (99)	Tracing board	136	.82	.90*
		Tracing path	136	.97	.98*
1929	Goodenough and Brian (23)	Ring toss	20	.90	
1930	Goodenough and Tinker (24)	Tapping (rt. hand)	30	(pencil) .85* (stylus) .87*	
1930	Hicks (30)	Moving target	60		.94*
1930	Long (57)	Archery (6th-grade boys)		.93 to	.98*

*Raised by Spearman-Brown prophecy formula.

With one exception, reliability coefficients run slightly higher for the experimental group, which has the longer learning period and for whom practice was consecutive. In view of the fact that the control group had a six-weeks forgetting period interposed between the fourth and fifth days of maze practice, it is surprising that the two series of coefficients so closely approximate each other. There seems to be no consistent tend-

ency towards higher reliability for either simple or complex, but reliability coefficients for errors show a consistent tendency to be lower than those for time.

In general, reliability coefficients obtained in this study agree with other recent human maze studies (42, 68, 74, 83). They run a little lower than those found by McGinnis (63) for the Young slot maze with a group of preschool subjects, but considerably higher than similar coefficients on a non-visual stylus maze.

Table 11 gives reliability coefficients reported in studies of preschool subjects where other motor skills were investigated. They are of about the same magnitude as reliability coefficients of the rolling-ball maze.

III

MEASUREMENT OF MAZE LEARNING

LEARNING CURVES

Learning curves based upon raw time and raw error scores of the experimental and control groups were drawn. The three maze patterns, representing three levels of difficulty, give clearly distinguishable curves; in no case do they overlap. They give the usual negatively accelerated curve with rapid improvement in the beginning and a gradual slowing up as practice continues. Since time and error decrease with improvement in skill, the curves descend as practice continues. The two types of curves are similar in general form, time being more regular than error. The first section, indicated by a vertical line, represents the initial practice of four days that was given to all subjects, and upon which pairing into experimental and control groups was made. The next 26 days were given over to daily practice for the experimental group while the controls rested. Then followed eight days of daily practice for both groups, referred to as the test series. A period of approximately two months of forgetting for all subjects was terminated by a retest of eight days.

Learning curves clearly indicate that the experimental group at the end of the practice period is superior to the unpracticed control group, and that this superiority is greater upon the complex task than upon the simple one. Here we see the differentiating effect of specific maze practice in bringing subjects to a

higher level of performance. Furthermore, the factor of complexity of maze pattern seems to be directly related to the amount of improvement in skill brought about through practice, for experimentals surpass controls slightly, if at all, upon the simple pattern, markedly upon the pattern of intermediate complexity, and to an even greater degree upon the most complex pattern. In other words, the effectiveness of practice in building up this motor skill increases with increasing complexity of task.

TIME CURVES

Initial Practice Period. The two groups start out about equal in maze ability on the first day. In each of the three maze patterns, the controls are slightly superior to the experimentals. By the end of the fourth day, however, this advantage is reversed and the experimentals have a slightly better record of performance.

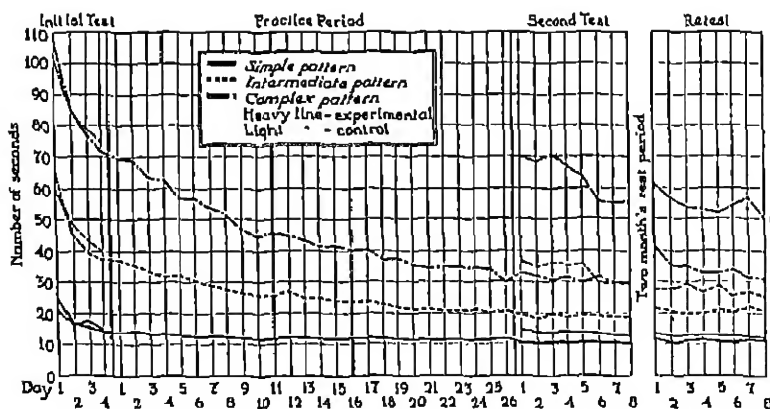


FIGURE 2
LEARNING CURVES FOR TIME SCORES

TABLE 12
DIFFERENCE BETWEEN TIME MEANS ON THE FOURTH DAY

Pattern	Control mean	Experimental mean	Diff. $\sigma_{diff.}$	D/ $\sigma_{diff.}$
I	15.05 \pm .24	13.95 \pm 1.74	1.10 \pm .59	1.86
II	40.26 \pm 8.90	37.38 \pm 8.54	2.88 \pm 2.47	1.17
III	74.90 \pm 14.63	71.50 \pm 16.41	3.40 \pm 4.40	.77

It was not possible to determine whether this reversal of better score from the first to the fourth day was indicative of higher maze ability on the part of the experimentals, who, though they began at a disadvantage, attained greater proficiency by the fourth day, or whether this occurred merely by chance. Table 12 shows these differences to be small, and well within the limits of chance variations.

Comparison of Learning for Experimentals and Controls. The experimental group shows rapid increase in skill during the practice and test periods. There is steady improvement in Pattern I until the 31st day, after which no noticeable gain is apparent, whereas for Patterns II and III improvement continues throughout the experiment. The control group also improves during the experiment, but the gain is relatively small. As the result of its 26 days of practice, the experimental group has attained a higher level of maze ability than the control group, and the difference between the two groups increases in magnitude as the level of complexity increases. On Pattern I in the test series, the experimental group shows a slight superiority over the control group. This superiority is somewhat greater for Pattern II, and still more

marked for Pattern III. The same relationship between amount of gain and complexity of task holds during the retest after two months of non-practice. The difference between performance of the two groups is not as marked as during the test period but is still present 60 days after the termination of maze practice. Since other conditions were identical for the two groups, the additional maze practice given the experimental group seems to be responsible for its higher level of functioning. As judged by these curves, the more difficult the task, the greater the influence of specific training. At the end of the practice period, and also 60 days later, the highly trained subjects do little better than the less practiced subjects on the easy maze pattern. Their superiority, according to time scores, is marked on the intermediate pattern, and it is of still greater magnitude on the most complex one.

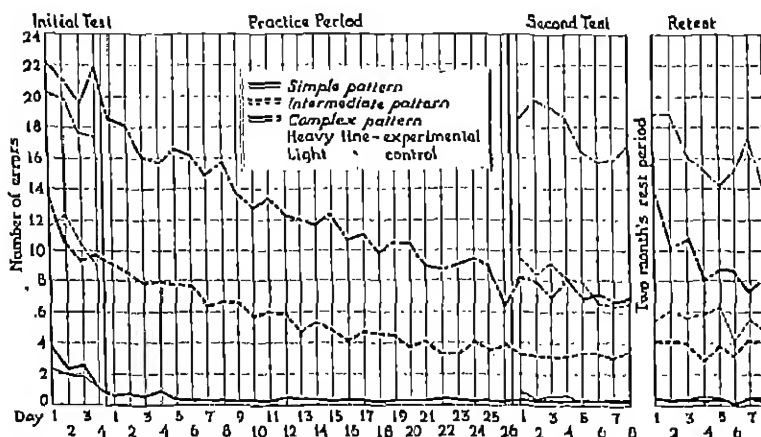


FIGURE 3
LEARNING CURVES FOR ERROR SCORES

ERROR CURVES

Initial Practice Period. The control group, as in the case of time scores, starts out with better performance on the first day of maze practice, but unlike those of time, the error scores of the control group continue to be superior on the fourth or last day of initial practice. Only in Pattern I do the experimentals overtake

TABLE 13
DIFFERENCE BETWEEN ERROR MEANS ON THE FOURTH DAY

Pattern	Control mean	Experimental mean	Diff. $\sigma_{diff.}$	D/ $\sigma_{diff.}$
I	1.25 \pm 1.07	1.15 \pm 1.06	.09 \pm .30	.30
II	9.14 \pm 3.24	9.90 \pm 3.79	.76 \pm 1.00	.76
III	17.68 \pm 3.33	22.56 \pm 8.32	4.88 \pm 1.80	2.71

the controls. Here again the differences are small and, with the exception of Pattern III, the critical ratios are statistically insignificant. It would seem from this analysis of time and error scores during the first four days of practice that differences in maze ability in the experimental and control groups, since they are slight and inconsistent in direction, can be attributed to chance variation. It has, therefore, been assumed that the two groups in the beginning of the experiment are approximately equal in maze ability, and that differences which may appear later in the learning process cannot be attributed to initial superiority. Since other factors such as initial ability, chronological age, mental age, and time-spacing of test and retest periods are approximately the same for both groups, we may conclude that the 26 additional days of maze practice

given to the experimental group account for this difference in level of ability. There is also the suggestion that the complex task profits more from specific practice than the simple task, since experimental and control groups are more nearly alike on Pattern I than on Pattern III. This harmonizes with the study of Gates and Taylor (18) who found in the simple task of speed of tapping that practice did not differentiate between experimental and control groups.

Comparison of Learning for Experimentals and Controls. The experimental group shows steady decrease in errors throughout the 38 days of practice. In Pattern I, a low record of .25 errors was attained on the 15th day, after which there was no further improvement. Additional practice brought slight fluctuations but no increased ability. It seems as if the physiological limit, beyond which practice is not effective, was reached at about this point. A similar stage of accomplishment was not reached in this pattern for time scores until the 31st day when the maze was traveled in 1.1 seconds. On neither of the two more difficult patterns, judging from the form of the learning curve, did subjects reach the limit of improvability in time and error scores.

The experimental group is superior to the control group in both the test and retest periods. As was noted for time, the difference between these two groups according to error scores increases with increasing complexity of maze pattern.

QUANTITATIVE MEASUREMENTS OF MAZE LEARNING

The attempt quantitatively to measure improvement is beset with difficulty. Kincaid (49) warns against too great confidence in any one method of analysis. She suggests four different types of measure and advises the use of more than one in any study of learning. These are: comparison of absolute differences at the beginning and end; comparison of relative differences at the beginning and end; relation of initial to gross gain; and relation of initial to relative gain. Peterson and Barlow (75) point out the weakness in using absolute units of measurement and recommend the coefficient of variability in studying the effect of practice upon individual differences. In this study, one is faced with the problem of inequality of units of measurement. Three tasks, varying in degrees of difficulty, are to be compared with each other. The elimination of one error or second of time would presumably represent different rates of progress in Pattern I than in Pattern III. How can one interpret the learning curves just described? Also, units change during the progress of learning. An error does not mean as much at the beginning of learning when ability is at a low level as it does when performance is highly skilled. Realizing the inadequacies of any one method of analysis in attempting to give a true picture of the learning process, several different measures of improvement have been used.

DIFFERENCE BETWEEN MEANS

Mean scores show the same tendency that was noted in the learning curves for experimentals to surpass the controls, and for this difference between the performance of the two groups to increase with the complexity of the maze pattern. This is illustrated in Tables 14 and 15.

Time. Table 14 gives the mean time scores during three different segments of learning for the experimental and control groups. At the beginning, represented by the initial period, the two groups are fairly equal in ability on each of the three patterns. The difference between means is small, ranging from .02 to 1.52, and the critical ratios are all well below the standard for statistical significance. The test period finds the experimental group superior to the control on all three patterns. The actual difference in means ranges from 2.71 to 32.94 with critical ratios large enough to insure its being a true difference. The retest again shows the experimental group superior, though here the difference is not so great as was noted for the test period, ranging from 1.37 to 20.68. Here again the critical ratios are above three.

Errors. The same trend appears for error scores as is shown in Table 15. The experimental group starts out equal to the control group, but, as the result of its additional practice, attains a higher level of performance by the test and retest periods. The difference between groups is less marked in the case of errors than for time scores, and the difference divided by the stand-

TABLE 14
MEANS AND DIFFERENCES OF TIME SCORES FOR EXPERIMENTAL
AND CONTROL GROUPS

Pattern	Mean	Difference	$D/\sigma_{diff.}$
<i>Initial</i>			
Pattern I			
Experimental	17.83 ± 2.17	$.02 \pm .72$	.03
Control	17.81 ± 2.90		
Pattern II			
Experimental	47.08 ± 8.70	1.52 ± 2.27	.67
Control	48.60 ± 7.30		
Pattern III			
Experimental	84.98 ± 14.24	$.36 \pm 4.11$	.09
Control	85.34 ± 14.78		
<i>Test</i>			
Pattern I			
Experimental	$10.84 \pm .62$	$2.71 \pm .40$	6.73
Control	13.55 ± 5.12		
Pattern II			
Experimental	18.82 ± 2.85	15.00 ± 1.17	12.80
Control	33.82 ± 5.12		
Pattern III			
Experimental	30.86 ± 6.16	$32.94 \pm .30$	14.34
Control	63.80 ± 9.70		
<i>Retest</i>			
Pattern I			
Experimental	$11.07 \pm .71$	$1.37 \pm .37$	3.73
Control	12.44 ± 1.56		
Pattern II			
Experimental	20.18 ± 7.55	7.09 ± 1.29	5.51
Control	27.27 ± 5.08		
Pattern III			
Experimental	34.00 ± 7.55	20.68 ± 3.08	6.71
Control	54.68 ± 12.32		

ard error of the difference in only half of the test and retest patterns is above three. However, the difference is always consistently in favor of the experimentals.

Tables 14 and 15 also show a consistent trend for the magnitude of the difference between groups to increase with increasing complexity of maze pattern. This ap-

plies only to the test and retest periods, for they alone are affected by unequal amounts of practice given the two groups. Apparently the more complex the task in this type of maze learning, the greater the difference between attainment of practiced and unpracticed subjects. This trend is found in both time and error scores.

TABLE 15
MEANS AND DIFFERENCES OF ERROR SCORES FOR EXPERIMENTAL
AND CONTROL GROUPS

Pattern	Mean	Difference	D/σ_{diff}
<i>Initial</i>			
Pattern I			
Experimental	2.43± 1.47	.63± .355	1.78
Control	1.80± 1.01		
Pattern II			
Experimental	10.90± 3.48	.01± .804	.01
Control	10.89± 2.03		
Pattern III			
Experimental	21.15± 5.35	2.30±1.247	1.84
Control	18.85± 3.12		
<i>Test</i>			
Pattern I			
Experimental	.29± .16	.19± .07	2.65
Control	.48± .30		
Pattern II			
Experimental	3.14± 1.51	4.80± .584	8.21
Control	7.93± 2.50		
Pattern III			
Experimental	7.54± 3.04	10.21±1.008	10.13
Control	17.74± 4.02		
<i>Retest</i>			
Pattern I			
Experimental	.37± .28	.06± .096	.67
Control	.44± .36		
Pattern II			
Experimental	3.89±1.96	1.11± .698	1.60
Control	5.00± 2.62		
Pattern III			
Experimental	9.55± 3.04	5.82±1.38	4.27
Control	15.36± 5.71		

RATIO OF EXPERIMENTAL MEAN TO CONTROL MEAN

In order to eliminate, so far as possible, the influence of inequality of units of measurement, ratios were worked for each of the three segments of learning by dividing the mean score of the experimental group by the mean score of the control group. Here we are not referring to absolute scores at any particular period but merely to the relation of one group to another. Table 16 presents these data. Each ratio has been multiplied by 100 to remove decimals. If pairing had been perfect, the initial ratios for each of the three patterns would have been 100, indicating identical scores for both experimentals and controls. As will be seen, the ratios actually obtained closely approximate this in time, and fairly closely in errors. It was pointed out in the preceding section that, according to means, the more difficult task profited most from an equal number of practice trials, and also that the differences between the means of the experimental and control groups gave increasing advantage to the experimental

TABLE 16
RATIOS OF MEAN PERFORMANCE OF THE EXPERIMENTAL AND
CONTROL GROUPS

Practice	Pattern I	Pattern II	Pattern III
<i>Time</i>			
Initial	100	97	100
Test	80	56	48
Retest	89	74	62
<i>Errors</i>			
Initial	135	100	112
Test	61	40	43
Retest	85	78	62

TABLE 17
CORRECTED RATIOS OF MEAN PERFORMANCE OF THE EXPERI-
MENTAL AND CONTROL GROUPS, MAKING IN EACH
CASE THE INITIAL RATIO 100

Practice	Pattern I	Pattern II	Pattern III
<i>Time</i>			
Initial	100	100	100
Test	80	58	48
Retest	89	76	62
<i>Errors</i>			
Initial	100	100	100
Test	45	40	38
Retest	63	78	55

group as one proceeds from simple to most complex pattern. The ratios here indicate the same tendency of greater difference between the two groups on test and retest scores from Pattern I to II, and from Pattern II to III. This is represented by the decreasing magnitude of the ratios. In the initial series the ratios remain about the same, clustering around 100, and show no consistent shift with changing pattern. The ratios of the test series are all well below 100, demonstrating that the practice group gives better maze performance than the controls. Furthermore, ratios tend to decrease in size from Pattern I to Pattern III. This holds for both error and time scores with one exception; Pattern III error test series, which is slightly larger than that for Pattern II. Retest ratios show the same trend.

Since the initial ratios only approximated 100, the ratios of the three patterns cannot in fairness be compared directly with one another. In order to correct this difficulty, each ratio of the test and retest series was

divided by its initial ratio for the same pattern. By this method, ratios have been obtained representing what would have resulted if pairing at the beginning had been perfect. On the basis of these corrected ratios, direct comparisons between the different patterns is possible. Table 17 presents this material. Here again there is a single reversal of the tendency for experimentals to profit relatively more than controls by practice on the more difficult tasks. The ratio for Pattern II, error score, is considerably larger than that of Pattern I, whereas in all other instances the reverse trend is apparent.

COMPARISON OF GAINS

Percentage of Gain. Table 18 gives the percentage of gain from initial to test periods for the two groups. It will be remembered that the time intervals between these two segments of learning are the same for both groups. However, during this interval of 46 days, the controls rested from practice while the experimentals received 26 daily practice periods. As a result of this additional practice for the experimental group, its relative gain is uniformly greater. Experimentals show gain on all three patterns according to time scores which range from 39% to 64%. In time scores, the controls gain from 23% to 30%. One of the control subjects, instead of gaining, made a loss of .8%. The same tendency for the experimentals to make relatively greater gain than the controls is shown by error scores. With the exception of a single subject on Patterns II and III, all members of the experi-

mental group gained. The magnitude of gain according to error scores is from 64% to 82%. Controls, on the other hand, gained from 19% to 65% on the same patterns. Moreover, three control subjects lost on Pattern II, and nine subjects lost on Pattern III. We find, therefore, a definite trend for experimentals to gain more than controls between initial and test periods. According to percentage of gain, the difference between the two groups increases with increasing difficulty of pattern. For time, this difference between percentage of gain of experimental and control groups

TABLE 18
MEAN OF PERCENTAGES OF GAIN OR LOSS FROM INITIAL TO
TEST PERIODS

Pattern	N	Experimentals Gain	N	Loss	N	Controls Gain	N	Loss
<i>Time</i>								
I	25	38.6± 6.09	—	—	25	23.1± 8.86	—	—
II	25	58.9± 7.64	—	—	25	29.9±15.76	—	—
III	25	63.9± 7.92	—	—	24	25.3±13.35	1	.80
<i>Errors</i>								
I	25	82.3±18.08	—	—	25	65.1±26.32	—	—
II	24	72.0±15.14	1	18.7	22	34.6±16.97	3	15.8
III	24	63.8±15.30	1	00.3	16	19.4±14.13	9	24.7

TABLE 19
MEAN GAIN OR LOSS FROM INITIAL TO TEST PERIODS

Pattern	N	Experimentals Gain	N	Loss	N	Controls Gain	N	Loss
<i>Time</i>								
I	25	7.0± 1.99	—	—	25	4.3± 1.94	—	—
II	25	28.0± 7.74	—	—	25	15.5± 9.20	—	—
III	25	54.3±14.64	—	—	24	22.3±12.94	1	.60
<i>Errors</i>								
I	25	2.2± 1.42	—	—	25	1.3± .93	—	—
II	24	8.2± 3.31	1	.75	22	3.76± 2.36	3	1.57
III	24	14.0± 6.11	1	.04	16	3.93± 3.60	9	4.18

amounts to 16 for Pattern I, 29 for Pattern II, and 39 for Pattern III. For errors, it is 17, 37, and 45.

Absolute Gain. Absolute gain (see Table 19), like percentage of gain, is greater for the experimentals than for the controls. This is true of both time and error scores. Also, the magnitude of the difference in gain of the two groups increases with difficulty of pattern.

Summary. A comparison of learning curves shows that, of two groups, starting out approximately equal in performance, the subjects having 26 additional days of practice were superior in maze ability to those who merely rested during this period. This tendency towards greater proficiency of the practiced group stands out clearly for both time and error curves. There is a consistent trend for the more complex task to profit more than the simple task from the additional practice given to the experimental subjects. There is little or no superiority for the practiced group at the test period on Pattern I; a marked superiority on Pattern II, and a still greater superiority on Pattern III. The same relationship holds for the retest which followed two months of forgetting, though to a less marked degree.

Four measures of maze learning were used in a quantitative analysis. These were: the difference between means of the practiced and unpracticed groups for the initial, test, and retest periods; the ratios of the practiced to the unpracticed groups for the same three periods; absolute gain for the two groups; and percentage of gain for the two groups. According to all four types of analysis—two based upon absolute differences and

two upon relative differences in maze learning—we find the same tendency for practiced subjects to be superior to unpracticed subjects as a result of their specific maze practice. Also, these measures support the conclusion that the gain of the practiced group over the unpracticed group increases with increasing difficulty of task, since it is consistently greater on Pattern II than on I, and on Pattern III than on II.

IV

RELATION OF MAZE PERFORMANCE TO OTHER FACTORS

RELATION TO INTELLIGENCE

In general, intelligence test scores seem not to be closely related to ability in motor skills. At the pre-school level, Goodenough and Brian (23) obtained a coefficient of $-.35$ between number of successful throws in a ring-toss game and intelligence. Hicks (30) found a correlation of $.05$ between initial ability in hitting a moving target and mental age when chronological age was held constant. For children between 3 and 13 years, Johnson (46) reports a coefficient of $.03$ between Smedley dynamometer scores and mental age with chronological age constant. Minnesota Mechanical Ability Tests (68), made up of 15 tasks involving varying degrees of motor skill, yielded correlations with intelligence quotients, for a group of high-school boys, ranging from $-.32$ to $.53$. Studies of motor ability in adults generally give the same low positive relationship. Skill correlated with college entrance examinations at a magnitude of $-.33$ to $.23$ in a series of 8 motor tests investigated by Seashore (80). Myers (66) concludes that there is no relation between card sorting and intelligence.

Intelligence and Complexity. There is a suggestion in two studies concerning the relation between intelligence and learning that intelligence tests are a better measure of ability in a complex than in a simple task.

Ruch (78), investigating three levels of complexity in task, finds an increasing relation between mental age and achievement when chronological age was held constant. Between intelligence and the specific tasks, he obtains coefficients of .18, .67, and .80 as one progresses from card sorting to code substitution to abstract relations. Atkinson (1) similarly finds indication in a study of card sorting, number-code substitution, and number-alphabet substitution, of an increasingly closer relation between intelligence and learning ability in complex tasks. In a theoretical discussion of skill, Pear (69) points out that isolated motor performances give a low or negative correlation with each other and with intelligence, but states, "In skilled performances a higher, more complex power might employ and coordinate the simple mechanism" (69, p. 201). In the present study, because of its ambiguity of meaning, the term complexity has been strictly defined as that quality which makes one of two otherwise similar tasks require a longer time and involve a greater number of errors. This definition of complexity in terms of time and error scores for the rolling-ball maze may account for the lack of agreement with the studies of Atkinson and Ruch. Certainly there is no tendency, as seen in Table 20, for intelligence quotients to be more closely related to skill on the most complex maze pattern than on the simplest one.

Intelligence and Maze Ability. In agreement with studies on other motor skills, maze literature reveals a small degree of relationship between intelligence test scores and maze ability. McGinnis (63) obtained co-

efficients ranging from .10 to .66 between intelligence quotients and initial trial on the Young slot maze for a group of preschool children. Later, a group of these same children learned a concealed-cue maze, and the coefficients between scores on this and intelligence were much lower, $-.024$ and $-.04$. McGinnis points out that on the concealed-cue maze there was no opportunity for visual aids and a trial-and-error method of approach was resorted to by necessity. In the field of adult learning, maze performance seems to be slightly related to intelligence. Hunter (37), Warden (95), and Peterson and Allison (74) report coefficients of from $-.45$ to $.37$ between scores on different intelligence tests and maze skill. A recent study by Spence and Townsend (83) reveals a "large and significant" difference between subjects of high and low intelligence test ratings. Coefficients from $.46$ to $.66$ were obtained between Thurstone tests and different measures of maze ability. It must be pointed out that this study, which is out of line with other work in the field, is based upon a small number of subjects, and that these subjects rep-

TABLE 20
CORRELATION COEFFICIENTS OF TIME AND ERROR SCORES
WITH INTELLIGENCE

Pattern No.		Maze performance		Time		Errors	
				<i>r</i>	P.E.	<i>r</i>	P.E.
I	50	Initial	4 days	$-.42$	.08	$-.34$	.08
II	50	Initial	4 days	$-.35$	.08	$.034$	.10
III	50	Initial	4 days	$-.176$	.03	$-.16$	.09
I	25	Mean	38 days	$-.20$	.13	$-.04$	.09
II	25	Mean	38 days	$-.28$	.12	$-.06$	.09
III	25	Mean	38 days	$-.166$	.13	$-.04$	.09

resent two selected groups of high and low intelligence ratings. Under these conditions one would expect to find marked differences between maze performance.

Table 20 gives correlation coefficients between intelligence quotients and time and error maze scores. There is, as will be seen, a small positive relationship between intelligence as determined by IQ and rolling-ball maze ability. Since time and error scores are being used, a negative correlation in reality represents a positive relationship. In this case, coefficients are all small, most of them are not significant, and they show no tendency to increase in magnitude with increasing difficulty of task. There is, however, an indication that intelligence is a better measure of initial ability than of later performance since with one exception coefficients between intelligence quotients and the first four days of practice run somewhat larger than those for intelligence quotients and the mean of 38 days' practice.

SEX DIFFERENCES

Figures 4 and 5 show learning curves of the boys and girls on the three maze patterns. It must be remembered that, in dividing according to sex, groups become very small, containing only 12 and 13 subjects, so that any conclusions as to sex differences can only be considered as suggestive. However, sex differences, if present, would probably show up in consistent trends common to both experimentals and controls and in both time and error scores. We find no consistent tendency for either sex to be superior in maze performance on any of the patterns or for any part of the learning

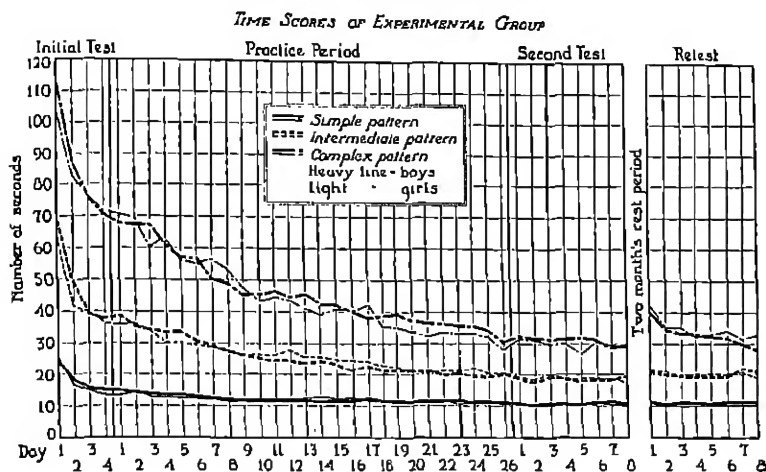


FIGURE 4
SEX COMPARISONS IN TIME SCORES

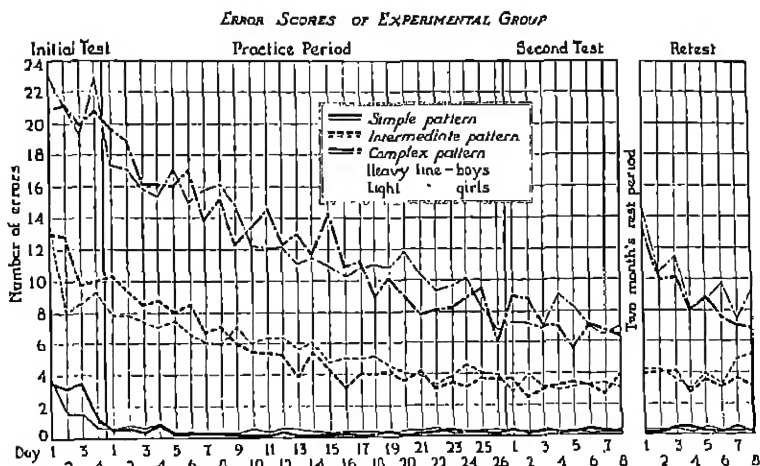


FIGURE 5
SEX COMPARISONS IN ERROR SCORES

period. This is contrary to the findings of McGinnis (63), who, for a group of preschool subjects learning the Young slot maze, reports a superiority in favor of the boys at the beginning of the practice period, but found that girls tended to catch up as learning progressed. Young (105), on the same maze and with a large number of subjects, found a large and consistent sex difference in favor of the boys.

In general, sex differences have not been established for motor learning at the preschool level. Boys excelled girls in throwing a rope ring (23), but girls improved more than boys. Sex differences in favor of boys were also found in throwing at a moving target (30). Wellman (99) found no sex differences in either tracing-board or tracing-path skill. A summary of sex differences in mental traits by Goodenough (22) points out that the question of sex precocity must be answered in terms of specific abilities; this seems also to be true for motor skills.

LEARNING DURING NON-PRACTICE

During the practice period of 26 days, the experimental group, with small variations, decreased in time scores, and this evidence of learning continued during the 8 days of testing. The control subjects, after the equivalent of 26 practice days, during which time they rested from maze practice, began the test with performance superior to their last record. In other words, maze ability increased during the interval without practice so that subjects were able to complete the three maze patterns in less time than they had been able to

previously. The gain is small, but is apparent for all three patterns, and it increases with difficulty of pattern. For Pattern I, the saving amounts to $\frac{1}{2}$ second; for Pattern II, 3 seconds; and for Pattern III, $4\frac{1}{2}$ seconds. This gain in ability during a period of non-practice may indicate the operation of a growth or maturation factor. It is small but consistent. The interval of time between the two practice periods for the control group is about 46 days. While the time span is short, it may be sufficient to bring about measurable increase in skill in these young children. It may be, however, that the environment, though lacking in actual maze practice, furnished practice of a more general nature, building up simple skills that contributed to maze ability. There seems to be no clear-cut way of separating out these two influences of general practice and maturation.

Other workers with preschool children have reported similar progress in motor skills during periods of non-practice. Goodenough and Brian (23), in a ring-toss learning experiment, found that short interruptions of practice, caused by absence and school holidays, usually brought with them a change in the form of the learning curve that, for some children, was improvement; for others, regression. In experiments on tapping and on auditory memory for digits, Gates and Taylor (17, 18) found that the control groups, after a period of non-practice, improved in performance. Hicks (30), with a moving target, found that controls showed steady improvement throughout the experiment even though an 8-weeks non-practice period was

interposed. Hicks (31) also reports for such skills as strength and perforation an increase in ability following 72 days of rest. The tracing-path test, given at the same time, showed a loss after the rest period.

Book (2), for typewriting of a single adult, found that speed increased during a year and a half of non-practice, but that accuracy did not; the number of errors actually increased. Book explained his subject's increase in speed as due to "disappearance, with the lapse of time, of numerous psycho-physical difficulties, interfering associations, bad habits of attention, incidentally acquired in the course of learning, which as they faded, left the more firmly established typewriting associations free to act" (2, p. 107). Watson (96) explains this seeming increase in skill during rest from practice as due to stopping on a spurt. If such was the case, the improvement was apparent rather than real. He stresses the permanency of explicit habits and skills and great rapidity in relearning due to memory. Cleveland (10) attributed increased skill in chess, following periods of rest, in terms of renewed interest and vigor, and also to the assimilation of impressions that had come so fast as to be confusing. In the field of animal learning, Heron (28) reports, in the learning of a problem box by rats, that a 60-day rest interposed between two periods of practice resulted in large amounts of learning as measured by time scores. Hence such gain during a period of rest is not without precedent in the literature on learning.

Later, two months of rest did not bring the consistent improvement in skill that was noted earlier in

ing process. The controls start the retest, a second test given to all subjects after a 2-interval of forgetting, with poorer time scores ended the 8-day period on two of the pattern the experimentals start with poorer scores free patterns. Table 21 gives the magnitude of gain that occurred during this 2-months was interposed between the test and retest per-

TABLE 21
GAIN DURING TWO MONTHS OF NON-PRACTICE
INTERPOSED BETWEEN TEST AND RETEST PERIODS*

Experimental	Control
Loss 1 sec.	Loss $\frac{1}{2}$ sec.
Loss 4 sec.	Gain $1\frac{1}{2}$ sec.
Loss 12 sec.	Loss $6\frac{1}{2}$ sec.

* the last day of the test and the first day of the retest.

seems from these data that improvement during periods of non-practice bears inverse relation to the level of skill attained by the subjects. In the case of rolling-ball maze learning, after four days of practice, gains following rest ranged from $\frac{1}{2}$ to $4\frac{1}{2}$ seconds. For the control group with 12 days of practice and two rest periods, performance varied from a loss of $1\frac{1}{2}$ seconds to a loss of 6 seconds. For the experimental group that practiced 38 days before rest, there was no loss; the loss ranged from 1 to 12 seconds. It may be concluded that the controls, being in a stage of relatively rapid learning, were on a spurt and so, according to Watson's theory, lose less than the experimentals. This factor of the learning curve and the point at which periods of non-practice are interposed may explain in

part the seeming inconsistent results of different motor learning studies.

Errors. The control group after 46 days of rest does not show the same consistent tendency for error scores to begin at a higher level of performance than was noted for time scores. Pattern I alone makes a gain of .75 errors. In Pattern II, a loss of 1.0, and in Pattern III a loss of 1.25 errors occurs. Resumption of practice after a 2-months period of rest brings loss rather than gain in maze ability, as measured by both errors and time. Only for Pattern II, control group, is there evidence of learning during non-practice. Table 22 gives the magnitude of loss or gain during the for-

TABLE 22
LOSS OR GAIN WHICH OCCURRED DURING TWO MONTHS OF NON-PRACTICE INTERPOSED BETWEEN THE TEST AND RETEST PERIODS*

Pattern	Experimental	Control
I	Loss .35 errors	Loss .13 errors
II	Loss .63 errors	Gain 1.00 errors
III	Loss 6.85 errors	Loss 2.00 errors

*Change between last day of test and first day of retest.

getting period. It is difficult to explain why there should be this tendency for subjects to decrease time but increase error scores during a period of rest from maze practice. Book (2) found the same thing for his adult learning to typewrite. Speed profited from a year and a half vacation but the number of errors increased. Heron (28) reports only saving in time for rats in relearning the problem box after 60 days of rest. Gates and Taylor (18) found that speed of tapping increased during six months of non-practice. The

time element certainly enters into moving-target skill, and this, in Hick's (30) study, showed higher level of performance for controls after eight weeks of non-practice. On the other hand, strength and perforation, which were also found to increase, seem not to be related so much to time as accuracy. The question cannot be answered from the data of this experiment, but there seems to be some corroborative evidence in the finding of other studies of motor skill that time scores tend to decrease and error scores increase during the same period of non-practice.

With errors, as with time, proficiency in skill following a period of non-practice seems to be inversely related to the level of attainment directly preceding the non-practice period. The control group with a relatively poorer performance, based on 4 days of practice, lost less during a 2-months rest than the experimental group with 38 days of practice. This shows up clearly in Table 22.

VARIABILITY

The question of whether individuals become more or less alike with practice has received considerable attention. Most of these investigations have been confined to mental functions, using adults as subjects. There is a good deal of contradictory evidence, some studies indicating that practice increases, others that practice decreases individual differences. This is not surprising when one considers that very different learning situations have been used; that groups vary in homogeneity, age, intelligence, and initial ability; and that

different statistical measures have been applied. Practice, according to Thorndike (88), increases individual differences. Kincaid (49), using four types of analysis of improvement, shows that the tendency for individual differences to increase or decrease with practice depends in some degree upon the particular statistical measures employed. In an analysis of 24 learning studies she finds inconsistent trends, but the weight of evidence supports the view that practice decreases individual differences. Peterson and Barlow (75) attempted to test out the theory that as a result of practice subjects would become more alike in simple tasks but less alike in complex tasks. They found for a group of 12-year-old children that differences tended to increase in digit-symbol substitution, judged to be the simplest; that they decreased in card sorting, a task of intermediate complexity; and that they increased in mental arithmetic, the most complex performance. These authors point out the need for further work and suggest that possibly the problems selected were too simple and that tasks of relatively greater complexity might bring increased individual differences.

Practice tended to increase variability in two studies of motor skill in preschool children. McGinnis (63), working with two types of mazes, a concealed-cue stylus maze and the Young slot maze, found that, according to three measures of absolute gain, percentage of gain, and coefficients of variability, differences between individuals increased with practice. Similarly, Hicks (30), with the moving target, found that coefficients of variability increased from initial to final per-

formance. There was a slight and unreliable increase in coefficients of variability for a group of sixth-grade boys in a study of dart throwing by Long (57).

Relation between Variability and Practice. Analysis of the effect of practice upon variability in this study has been made by comparing coefficients of variability, 100 sigma/mean. Tables 23 and 24 present these data. In our consideration of the relation between practice and individual differences, the experimental and control groups must be separated, for it will be remembered that the experimentals were given 38 consecutive practice days in the interval between the beginning of the initial and the end of the test periods. Since controls, on the other hand, had only 12 practice days and these were interrupted by a long rest period, their coefficients may be disregarded.

TABLE 23
COEFFICIENTS OF VARIABILITY FOR TIME SCORES—100
SIGMA/MEAN
Experimental

Period	Pattern I	Pattern II	Pattern III
Initial	12.18	18.49	16.76
Test	5.69	15.15	19.95

TABLE 24
COEFFICIENTS OF VARIABILITY FOR ERROR SCORES—100
SIGMA/MEAN
Experimental

Period	Pattern I	Pattern II	Pattern III
Initial	60.66	31.90	25.30
Test	56.36	43.07	40.25

According to time, coefficients of variability decrease on Patterns I and II but increase on Pattern III from the initial to the test period. Error coefficients of variability likewise show the tendency to decrease on the simple pattern and increase on the most complex pattern. The intermediate pattern is ambiguous, giving for errors an increase in variability, for time a decrease. The general trend of these data lends support to the theory that practice decreases differences in simple tasks and increases differences in complex tasks.

TIME AND ERROR SCORES

Table 25 shows the relationship between time and error scores of maze learning. With one exception the experimental group has the higher coefficients and this is true of the initial period of four days' practice which was identical for all subjects as well as later periods where differential practice has taken place. In general, coefficients are rather low, ranging from .21 to .90, with a mean of .53, indicating that these two measures represent somewhat different factors in the learning process.

Time and Error Coefficients as Affected by Practice. Table 25 shows the tendency for coefficients of correlation between time and errors to decrease with practice on the simple pattern, to remain about the same on the intermediate pattern, and to increase on the most complex pattern. Here, again, in studying the effect of practice upon the relation between these two measures of maze learning we must center our attention upon the experimental group, for they alone

TABLE 25
CORRELATION COEFFICIENTS OF TIME AND ERROR SCORES
Experimental

Pattern	No.	rho	P.E.
<i>Initial period—4 days</i>			
I	25	.50	.11
II	25	.79	.05
III	25	.66	.08
<i>Initial through test 26 practice days for experimental</i>			
I	25	.40	.12
II	25	.80	.05
III	25	.72	.07
<i>Retest period—8 days</i>			
I	22	.24	.14
II	22	.84	.04
III	22	.90	.03

received any considerable practice. On Pattern I, coefficients decrease in magnitude from initial through practice to retest periods. This seems to be attributable to two causes: individual differences are tending to decrease on this pattern as the result of practice as was shown by coefficients of variability, bringing about greater homogeneity in the group; and error scores are approaching zero and therefore become relatively undistributed. Pattern II remains about the same for different periods of the learning process. This may be the result of the ambiguity noted for this pattern in respect to variability as the result of practice. It will be remembered that for time scores coefficients of variability decreased with practice, while for error scores they increased. Pattern III shows an increase in correlation coefficients between time and error accompanying an increase in individual differences due to practice.

Coefficients of time and error scores seem to support the trend noted for variability; as practice continues they decrease upon the simple task, remain practically unchanged on the intermediate task, and increase upon the complex task.

INITIAL STATUS AND VARIOUS MEASURES OF GAIN

Table 26 gives correlation coefficients between initial status and performance at test and retest periods, also relative and absolute gain for time scores. Table 27 presents these same data for error scores. According to both time and errors, initial status is a poor measure of final accomplishment. Coefficients between initial and test, also between initial and retest, are uniformly small and generally insignificant. However, they tend to be positive. There seems to be no tendency for maze ability at the beginning or end of practice to be more closely related upon the simplest pattern

TABLE 26
CORRELATION COEFFICIENTS BETWEEN INITIAL STATUS AND TEST,
RETEST, ABSOLUTE GAIN, AND PERCENTAGE OF
GAIN FOR TIME SCORES

Correlation of initial and:	No.	Pattern I rho P.E.	Pattern II rho P.E.	Pattern III rho P.E.
<i>Experimental</i>				
Test	25	.46±.11	.36±.12	.32±.13
Retest	22	.00±.15	.45±.12	.37±.13
Absolute gain	25	-.92±.02	-.90±.03	-.82±.05
Percentage gain	25	-.81±.05	-.55±.10	-.34±.12
<i>Control</i>				
Test	25	.66±.08	.18±.14	.40±.20
Retest	22	.30±.14	.06±.15	.48±.12
Absolute gain	25	-.80±.05	-.76±.06	-.70±.07
Percentage gain	25	-.54±.10	-.63±.08	-.49±.11

TABLE 27
CORRELATION COEFFICIENTS BETWEEN INITIAL STATUS AND TEST,
RETEST, ABSOLUTE GAIN, AND PERCENTAGE OF
GAIN FOR ERROR SCORES
Errors

Correlation of initial and:	No.	Pattern I rho P.E.	Pattern II rho P.E.	Pattern III rho P.E.
<i>Experimental</i>				
Test	25	.02±.14	.17±.14	— .20±.14
Retest	22	.06±.15	.08±.15	— .11±.15
Absolute gain	25	— .98±.01	— .88±.03	— .80±.05
Percentage gain	25	— .59±.09	— .38±.12	— .55±.10
<i>Control</i>				
Test	25	.33±.13	.18±.14	.15±.14
Retest	22	— .52±.11	.19±.15	.04±.15
Absolute gain	25	— .93±.01	— .30±.13	— .52±.10
Percentage gain	25	— .56±.10	— .12±.14	— .58±.09

than upon the most complex pattern. Coefficients range from —.52 to .66, with a mean of .03 for errors, and a mean of .34 for time. This would indicate a small positive relationship between initial and final status.

Relative and absolute gain give negative correlations with initial status, but this, too, represents a positive relationship. In other words, those who start out with a low score in time and errors, indicative of high maze performance, also gained the most. Coefficients are noticeably higher for gain than for final status, ranging from —.12 to —.98, with a mean of —.60 for time, and a mean of —.68 for errors. Again there is no evidence that complexity of pattern affects the relationship between initial status and gain.

INTERMAZE RELATIONSHIP

Table 28 gives the correlations of different maze patterns with each other. This is based upon mean total

TABLE 28
INTERMAZE CORRELATIONS OF MEAN TOTAL SCORES FOR
EXPERIMENTAL GROUP

Pattern	No.	Time		Errors	
		rho	P.E.	rho	P.E.
I and II	25	.84	.04	.49	.11
II and III	25	.82	.05	.69	.07
I and III	25	.77	.06	.43	.12

scores of the experimental group over a learning period of 38 consecutive practice days.

These three patterns correlate among themselves more highly on time than error scores. This may be explained by the fact that time scores are of greater magnitude than errors, and have a greater range. This factor of heterogeneity would tend to raise the coefficients of correlation as compared with the more restricted error score range. Patterns representing contiguous levels of complexity, such as I and II, also II and III, are more closely related than the more widely separated Patterns I and III. Heron (27) similarly found that five different maze patterns for rat learning did not correlate equally with each other. In general, he obtained a small positive correlation, but this varied with the different patterns.

COMPARISONS OF THREE LEVELS OF COMPLEXITY AT DIFFERENT PERIODS

In an attempt to determine what is the effect of interpolated periods of practice or rest upon the relation between patterns differing in degree of complexity, mean time and error scores for initial, test, and retest periods were weighted by dividing the mean score of each pat-

tern by the mean score of the simple pattern for that period. This makes possible direct comparison for it shows what would be the relation of each pattern with every other one when the simple pattern is reduced to 1.00. Tables 29 and 30 present these data.

For the experimental group, whose intensive practice was followed by a two-months rest period, the relationship of the three patterns differing in degree of

TABLE 29
WEIGHTED SCORES OF EXPERIMENTALS SHOWING RELATION OF
THREE PATTERNS AT DIFFERENT PERIODS

Pattern	Initial Mean	period Ratio	Test period Mean	Ratio	Retest Mean	period* Ratio
<i>Time</i>						
I	17.83	1.00	10.84	1.00	11.07	1.00
II	47.08	2.64	18.82	1.74	20.18	1.82
III	84.98	4.77	30.86	2.85	34.00	3.07
<i>Errors</i>						
I	2.43	1.00	.29	1.00	.37	1.00
II	10.90	4.49	3.14	10.83	3.89	10.51
III	21.15	8.70	7.54	25.31	9.55	25.81

*Retest is a second test following two months of non-practice.

TABLE 30
WEIGHTED SCORES OF CONTROLS SHOWING RELATION OF
THREE PATTERNS AT DIFFERENT PERIODS

Pattern	Initial Mean	period Ratio	Test period Mean	Ratio	Retest Mean	period* Ratio
<i>Time</i>						
I	17.81	1.00	13.55	1.00	12.44	1.00
II	48.60	2.73	33.82	2.50	27.27	2.19
III	85.35	4.79	63.80	4.71	54.68	4.40
<i>Errors</i>						
I	1.80	1.00	.48	1.00	.44	1.00
II	10.89	6.05	7.93	16.52	5.00	11.36
III	18.85	10.47	17.74	36.96	15.36	34.91

*Retest is a second test following two months of non-practice.

complexity remains practically the same before and after the rest period as is indicated by the similarity of ratios of the test and retest periods in Table 29. In other words, after considerable practice, two months of rest did not change the relationship between tasks of different complexity. This is not true of the interval between the initial and test periods, covering about 46 days, of which 26 were devoted to practice. According to time scores, the experimentals tend to draw closer together on the three patterns, whereas error scores become more widely separated. Apparently by the end of the test period, performance has become pretty well stabilized so that a rest of 60 days does not change the relationship between different levels of complexity.

Time scores for the control group remain relatively the same on the three patterns at the beginning, after 46 days of rest, and following a later 60-day non-practice period. Error scores of controls follow those of experimentals in becoming more separated on the three patterns at the test period. However, unlike the experimentals, control error scores tend to become somewhat more closely related during the 60 days of non-practice.

In general, it may be said that the effect of two months of forgetting is to keep the relationship already existing between the three levels of complexity practically constant. The one exception to this rule is the control error scores for Pattern II where there is a tendency to approach the simple one. This indicates that by the test period sufficient stability in regard to the relationship between patterns has been established

so that interpolated periods of non-practice do not materially alter that relationship. The tendency towards stability is greater for the experimentals who have had considerable maze practice than for controls who have had much less maze practice.

Summary. Learning of this maze is related to intelligence to a very slight degree, but the magnitude of the relationship does not increase with the complexity of the task. No sex differences are apparent. The amount of learning or forgetting during a period of non-practice apparently depends upon the form of the learning curve at the time learning is interrupted. Individual differences increase with practice on the most complex task and decrease on the simplest. Stability of the ratios of the more complex tasks to the simplest one from the test to the retest period seems to indicate that forgetting proceeds at about the same rate in the three tasks.

V

SUMMARY AND CONCLUSIONS

Throughout this study the differentiating effect of level of complexity appears. Practice upon a relatively simple skill brings increased ability in that skill; however, a similar interval of time devoted to rest seems to give about the same result. Highly practiced individuals are not markedly superior to relatively unpracticed individuals on a simple task. This seems to be an established fact, and one that has influenced contemporary educational theory and practice. The results from this investigation show, also, that the complex task profits from practice, and that the degree of superiority of practiced over unpracticed individuals increases with increasing complexity of the task. Complexity seems to be the factor in determining whether time alone, or time spent in practice, is essential in producing skill of a high level.

Experimental studies give evidence that the influence of maturation and training vary with different skills. The data here presented lends support to the theory that 'level of complexity' is a potent factor in determining the relative influence of these two forces. When subjects are developing rapidly, i.e., when maturation is taking place, and when the skill is simple, as pencil tapping or a maze with few turns and no cul-de-sac, a few trials needed to adjust the individual to the particular situation plus an interval of time will bring performance to a high degree of proficiency. If, on the other hand, the skill be complex, as an intricate

maze pattern, considerable specific practice is required for efficient performance in addition to a given maturation level. When one takes such an everyday life situation as the running of an automobile, a comparatively simple skill for the adult, but vastly more complex than the most intricate maze pattern for children, the need for practice shows up even more clearly. Training cannot supplant inner growth, but training is a necessary supplement to intrinsic development when the skill to be acquired lies beyond the level of the very simple.

Level of complexity likewise determines whether individual differences will increase or decrease as the result of practice. Intensive training in a simple skill seems, according to the data of this experiment, to reduce members of a group to a common level of performance, whereas training in a complex skill tends to make individuals less alike. This would seem to agree with common-sense reasoning and finds support in other experimental work. This rôle of complexity harmonizes the viewpoints of hereditarians and environmentalists by emphasizing the importance of both nature and nurture in the learning process. For a very simple skill which taxes neither the intellectual nor physical endowment of the great mass of people, practice acts as an equalizer of environmental opportunity and makes individuals relatively more alike in performance. High level of ability in a complex skill may be beyond the native endowment of a considerable number of individuals. Continued practice in this skill would necessarily fail to bring such individuals

above the level of mediocrity, whereas for the more gifted ones practice would be highly effective. In a complex skill such as golf, performance ranges all the way from that of a Bobby Jones to that of the poorest player, and no amount of practice would ever bring those two extremes together. Those who hope to produce a race of supermen merely by the process of equalized opportunity and education are doomed to failure.

Educational implications from this study are chiefly those related to the influence of degree of complexity. Unfortunately, there is no satisfactory criterion for complexity; we can only roughly compare the relative degree of complexity in two dissimilar skills. But we do recognize gross differences in the complexity of activities going on about us, and readily distinguish between the two extremes of a given skill.

One cannot generalize from a specific motor skill to an intellectual problem. It would be interesting to follow up this study of motor learning with one where the task is primarily intellectual to see if the conclusions drawn here would apply equally well to that other type of activity.

The following conclusions are drawn from this experiment.

1. As a result of 26 days of training on the three rolling-ball mazes of different complexity, practiced subjects are superior to unpracticed subjects. This superiority is slight if at all upon the simple pattern, marked upon the pattern of intermediate complexity, and still more marked upon the most complex pattern. This conclusion is supported by graphic learning curves and by quantitative analysis of maze records.

2. This type of maze performance bears a slight positive relation to mental test ratings as is shown by correlation coefficients ranging for the three patterns from $-.42$ to $.03$.

3. No sex differences are apparent for this skill.

4. Whether loss or gain will occur after a period of non-practice, and how great it will be, is inversely related to the level of performance at the interruption of learning. Rest periods interposed during the early stages of learning when the curve is descending rapidly resulted in gain or only slight loss in skill, whereas rest periods coming later, at the time when the learning curve is flattening out, are followed by relatively greater loss in skill.

5. Individual differences tend to increase as a result of practice on the more complex task whereas they tend to decrease on the more simple task.

6. Consecutive mazes in the scale of complexity (i.e., I with II, and II with III) correlate more highly than those at the extremes (I with III).

7. After skill has been well established, a 60-day rest period does not affect the relationship between the tasks of different complexity, i.e., forgetting does not proceed more rapidly on the complex than upon the simple task.

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LA RELATION ENTRE LA COMPLEXITÉ DE L'HABITUDE À ACQUÉRIR ET LA FORME DE LA COURBE D'APPRENTISSAGE CHEZ LES JEUNES ENFANTS

(Résumé)

Dans le but de comparer la capacité d'apprendre dans les conditions de l'exercice limité et étendu et l'influence du repos ou non-exercice sur l'apprentissage dans des tâches de complexité diverse, on a fait trois labyrinthes de complexité diverse où l'on roule un boule. Cinquante élèves du jardin d'enfants, après quatre jours d'exercice dans les trois labyrinthes, ont été groupés en paires selon cette première exécution dans le labyrinthe et selon l'âge, le sexe, et le Q.I. Le groupe expérimental a subi ensuite vingt-six périodes d'exercice dans les labyrinthes, l'intervalle d'exercice s'étendant pendant une période de quarante-deux jours. On a testé ensuite le groupe expérimental et celui de contrôle au moyen d'une exécution de huit jours dans les labyrinthes. On n'a donné aucun autre exercice, mais après un intervalle de deux mois on a donné une répétition du test aux deux groupes.

Les courbes d'apprentissage et l'analyse quantitative des résultats des labyrinthes donnent les résultats suivants: Dans tous les trois labyrinthes les sujets exercés sont supérieurs aux non exercés. La supériorité du groupe exercé est petite pour la forme simple, marquée pour la forme de moyenne complexité, et grande pour la forme la plus complexe. Les différences individuelles résultant de l'exercice du groupe expérimental se sont accrues dans la tâche la plus complexe et ont diminué dans la tâche la plus simple. La forme de la courbe d'apprentissage au temps quand l'exercice est interrompu semble déterminer si le sujet perdra ou gagnera après un intervalle de repos. Quand l'exercice est interrompu pendant la période de progrès rapides dans l'apprentissage, l'exécution après la période de repos est seulement un peu inférieure quand on la mesure par le nombre d'erreurs et est même supérieure quand on la mesure par les résultats du temps. Quand l'exercice est interrompu à une période de progrès lents, c'est-à-dire, après que la courbe d'apprentissage a commencé à devenir horizontale et à approcher d'une limite physiologique, une période de repos cause une perte marquée dans les résultats du temps et dans ceux des erreurs. Après que l'habileté a été bien établie, une période de repos de six jours n'influe pas sur la relation entre les tâches de complexité diverse; c'est-à-dire, l'oubli est aussi rapide dans la tâche simple que dans la tâche complexe.

On semble justifié de conclure de ces données que la complexité de la tâche a une influence marquée sur l'efficacité de l'exercice, et que son influence est évidente dans la croissance des différences individuelles qui dérive de l'exercice.

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DIE BEZIEHUNG ZWISCHEN DER KOMPLIZIERTHEIT DER ANZUEIGNENDEN GEWOHNHEIT UND DER FORM DER LERNKURVE BEI JUNGEN KINDERN

(Referat)

In der Absicht, die Lernfähigkeit unter den Bedingungen der beschränkten und der verlängerten Übung und die Einwirkung der Ruhe oder der Nicht-Übung auf das Lernen bei Aufgaben verschiedener Kompliziertheit zu vergleichen, wurden drei, in Bezug auf den Grad der Kompliziertheit verschiedene, Irrgänge mit rollenden Kugeln [rolling-ball mazes] erfunden. Fünfzig Kinder aus Kindergarten wurden vier Tage an den drei Irrgängen geübt und dann in Bezug auf [gleiche] Leistung in dieser anfänglichen Irrgangtätigkeit und auf Alter, Geschlecht, und Intelligenzquotient, gepaart. Die Versuchsgruppe wurde dann 26 Mal an den Irrgängen geübt. Die Zeit der Übung erstreckte sich über 42 Tage. Sowohl die Versuchs- wie die Kontrollgruppe wurde dann an acht Tagen mit den Irrgängen geprüft. Es folgte keine weitere Übung, aber nach zwei Monaten wurden beide Gruppen nochmals geprüft.

Die Lernkurven und eine quantitative Analyse der Irrgangprotokolle liefern folgende Resultate. An allen drei Irrgängen zeigen sich die geübten Versuchspersonen als den ungeübten überlegen. Die Überlegenheit ist bei der einfachen Gestaltung [pattern] gering, bei der Gestaltung von mittlerer Schwierigkeit ausgeprägt, und bei der kompliziertesten Gestaltung gross. Individuelle Unterschiede infolge der Übung der Versuchsgruppe nahmen bei der kompliziertesten Aufgabe zu und bei der einfachsten Aufgabe ab. Die Form der Lernkurve zur Zeit der Unterbrechung der Übung scheint zu bestimmen, ob die Versuchsperson nach einer Ruheperiode fortschreiten oder zurückgehen wird. Wenn die Übung während einer Periode des raschen Fortschreitens im Lernen unterbrochen wird, so ist die Leistung, an der Zahl der Irrtümer gemessen, nach der Ruheperiode nur wenig niedriger, und, an dem Zeitverbrauch gemessen, sogar besser. Wird die Übung während einer Periode des langsamen Fortschreitens unterbrochen, d.h., nachdem die Kurve angefangen hat, platt zu werden und sich einer physiologischen Grenze anzunähern, so verursacht eine Ruheperiode einen ausgeprägten Verlust, sowohl in Bezug auf Zeit wie in Bezug auf Genauigkeit. Nachdem die Gewandtheit gut etabliert ist, wird die Beziehung zwischen Aufgaben von verschiedener Kompliziertheit durch eine Ruheperiode von 60 Tagen nicht beeinflusst; d.h., das Vergessen geht bei der einfachen Aufgabe eben so schnell von statten wie bei der komplizierten.

Es scheint auf Basis dieser Befunde der Schluss berechtigt zu sein, dass die Kompliziertheit der Aufgabe die Wirksamkeit der Übung stark beeinflusst, und dass diese Beeinflussung sich in der Vergrößerung der durch die Übung verursachten Unterschiede bemerken lässt.

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Figure 1

CARL MURKINSON, Chief Underdog

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**The Pedagogical Seminary and
Journal of Genetic Psychology**

Abstract

CARL MEDKESON, Clark University

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Texas*; William H. Burroughs, *Clark University*; Cyril Rice, *University of
London*; Leonard C. Clinebell, *Brooklyn University*; Ed. Clapenette, *University of
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Figure 1

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EATING HABITS IN RELATION TO PER- SONALITY DEVELOPMENT OF TWO- AND THREE-YEAR-OLD CHILDREN*

A STUDY OF SIXTY-NINE CHILDREN IN TWO NURSERY SCHOOLS

From the Graduate School of Education of Harvard University

By

ABIGAIL A. ELIOT

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INTRODUCTION

The importance of eating habits in relation to the child's nutrition has become widely appreciated. Pediatricians, nutritionists, psychologists, and educators have discussed at length how learning may influence eating and so affect physical development. That eating habits are also related to the child's personality development is not so generally recognized. A few writers in the field of child care and training suggest such a possibility, but, on the whole, the problem has received relatively little study and attention. This study was undertaken because of the lack of information on the subject and because of an increasing belief that there is a significant relationship between eating habits and the development of personality.

The term "eating habits" means, for the purposes of this paper, the child's habit of eating or not eating the food which is set before him. It does not include skill in handling spoon or fork, ability to convey food to the mouth without spilling, or other matters which might be summed up as "table manners," some of which Blatz included in his "Study of Eating Habits in a Nursery School" (7). Though it is recognized that personality is an integration of many psychobiological traits, in order to facilitate discussion four aspects of personality are considered in this study, those of the body, the intellect, the emotions, and the attitudes. The personality traits which have been chosen for study in relation to eating habits are classified under these four heads.

Why may a study of the eating habits of young children from the standpoint of their personality development be significant? If we agree with Dr. Gesell (23) that "these years (the preschool ones) determine character, much as the foundation and frame determine structure," we need only realize that eating consumes a large proportion of the time, attention, and interest of young children to find the answer to our question. It is an important subject for preschool education to consider because, in the total development of a human being, that which comes first influences all later development, and because eating looms so large as a factor in the lives of preschool children.

A newborn baby eats and sleeps, cries a little, moves a little, and eats and sleeps again. Almost his whole existence is given over to the activities necessary for physical growth. As the child grows older he sleeps a little less, he eats a little less frequently but just as eagerly, and he spends more time in bodily activity, more time in making noises with his voice, more time in becoming acquainted with his environment. After a while he gets up on his feet and explores his universe. He sleeps fewer hours out of the twenty-four, but food is just as important to him as ever. Perhaps eating as an activity looms even larger than before because now he is presented with new foods which he either accepts with interest or rejects with energy. He still eats three or four times a day, for his body must have plenty of food to provide for very rapid growth.

In the life of the runabout child, eating is just as important as ever for physical development. It has also

become important as a part of his world of things, people, and happenings. Everything connected with eating interests him intensely. It holds for him great and frequent possibilities of interest and delight. He sets about discovering these possibilities. Not only is there the joy of eating good food when he is hungry, but there is the interest of using the spoon and cup himself, the pleasure in new sensations of taste, smell, or touch, the delight of creating a reaction in other people when he flings his spoon on the floor, or spits out his cereal, or sets his teeth when his mother tries to feed him, the delight of gaining increased attention when he refuses to eat. In the minds of those who have watched, there is no doubt that mealtime is an important and interesting time to a little child.

A runabout child's interest in the eating situation is normally aroused by the satisfaction of appeasing hunger. But it is always to some extent, and often to a great extent, aroused by the satisfaction of exerting power over the world of things and people which surrounds him, a satisfaction which is found not only in the eating situation, but also in other situations of his daily life. If handling the spoon and cup skillfully brings a child satisfaction, he will be interested in so handling them. If eating whatever food has been provided gives a child a feeling of power, he will eat what is provided. If he gets a greater feeling of power out of refusing to eat, he will refuse. In either case his interest is aroused. The question of the development of eating habits is as simple and as complex as that. It is simple because of the fundamental psy-

chological principle that what brings a feeling of pleasure tends to be repeated. It is complex because of the sometimes apparent difficulty of arranging things so that good eating habits rather than bad ones are interesting.

An added reason for mealtime to loom large in the child's life is the attitude of concern which mothers have toward a little child's eating, a natural concern increased by the stress laid on diet by pediatricians and nutritionists. To some mothers the child's mealtime is of consuming importance, it is the chief worry of their lives. They know that no human being can survive without food. If the child refuses to eat or does not eat as much as is expected, the mother is beside herself with concern for his welfare. Without question, the child feels this concern, feels his power in having caused it, enjoys the attention it brings him, and so continues to refuse to eat. Often the mother may partly realize that giving in to the child by substituting another food for that which he refuses, or creating a scene by insisting that he eat, is bad for the child from the point of view of discipline or of emotional disturbance. She continues to feel, however, that the one important thing is that he should eat, so the scene or the giving in to his likes and dislikes continues, and the finickiness in eating, the display of power wrongly used, continues. This exaggerated emphasis on the necessity of eating cannot help but increase the influence which mealtime exerts on the child's life.

Eating is, of course, essential from the point of view of survival. But are not, also, the habits of eating im-

portant from the point of view of personality development? Thinking mothers, as well as those who are professionally interested in preschool education, deplore the situations which so often arise out of refusal of food because of their possible or even probable effect on the child's disposition. If the child is given his own way at one meal, he will demand it at the next. When this is repeated three or four times a day, and becomes a regular occurrence, does it influence the child's attitude toward other life situations? When food which is refused is forced and the scene which follows becomes a regular three-times-a-day affair, how does it affect the child's emotional life? Do some children have certain personality traits (either innate or acquired) which have a tendency to make them refuse food? To what extent, if any, does refusal to eat affect personality or vice versa? Is there any carry-over from what is learned in the eating situation to behavior in other life situations? It is such questions as these that have stimulated the present study.

II

THE PROBLEM OF EATING AS DISCUSSED IN THE LITERATURE ON CHILD CARE

The literature which deals with the care and training of young children discusses the problem of eating from three points of view: (1) diet as related to nutrition, (2) methods by which a child may be taught to eat the food which is offered him, and (3) the relation of eating habits to personality. Much has been written in recent years from the first point of view and new studies in the field of diet for young children are constantly appearing. One of the most interesting recent experiments is that which Dr. Clara M. Davis (14) is conducting in regard to the "self-selection of diet by newly weaned infants." Such studies give us information which may not only be far-reaching in its significance for nutrition but may also have a bearing upon the other aspects of the subject. The present paper, however, makes no attempt to deal with the nutritional aspect of eating. To some extent it is concerned with the question of methods of teaching children to eat, but its central interest is in the relation of eating habits to personality.

Numerous books on child care and management published recently have dealt at length with eating from the second point of view, an indication of how widespread is the problem of guiding eating habits. Aldrich (1), speaking of it as "one of the major problems of pediatrics," says, "At a recent meeting of the Chicago Pediatric Society this subject was thoroughly

discussed. It was stated by various men that between eighty-five and fifty per cent of the children who came to their offices presented the appetite problem in a more or less marked degree." Roberts (40), in an article on "The Prevalence of Non-Hunger among Children," refers to a study by Moseley (35a) of the appetites of 100 city children coming from comfortable and well-to-do homes. Nineteen of these children were considered very hungry,¹ 16 hungry, 24 dawdlers, and 41 problems in eating. It is striking that of this group only 35 ate well, as against 65 who were finicky or distinctly poor eaters. Another study, by Johnson (26a), to which Roberts refers, shows that among country children 62 were hungry and 38 non-hungry. The writer's own study shows that, out of 69 nursery-school children, 24 were finicky. Of the 45 non-finicky eaters some had previously been finicky. Physicians, psychiatrists, psychologists, nutritionists, and educators are acknowledging that the problem is one of considerable extent.

Many writers on the care and training of young children have given detailed and practical advice in regard to the handling of the child's mealtime for the purpose of preventing or curing anorexia.² They seem to feel that guidance of eating habits should be a part

¹The terms *hungry*, *good appetite*, *non-finicky*, are used by various authors to describe the child who eats well. The terms *non-hungry*, *poor or lack of appetite*, *finicky*, are used to describe the child who does not eat well. Anorexia is a synonym for loss or lack of appetite. By whichever term the children are described the problem is fundamentally the same.

²A list of discussions of how to get children to eat the food that is offered them will be found at the end of this section.

of the program of preschool training, and that, if such training is successful, the problem of finickiness and non-hunger will not appear in older children, and, what is more, malnutrition in older children will be markedly reduced. It is pretty well conceded by these authors that a child's attitude toward eating regularly a wholesome variety of food is, in the main, established in the earliest years at the time when the child meets his first changes in diet. The shift from breast to bottle is a crisis, the introduction of the first food other than milk is a crisis, the first presentation of solid food is a crisis, each new flavor, each new consistency, each new appearance, each new temperature may be, and often is, a crisis. Whether these crises are passed with ease and satisfaction, or whether they become occasions for battles which leave serious scars, depends largely on how each one is approached by the parent or nurse attending the child. Even the management of breast feeding in the first weeks of life may have a definite influence on eating habits, a matter that is relatively little appreciated by those responsible for its direction.

Among the writers who discuss methods of handling the eating situation those who have the clearest insight into the problem are the ones who are particularly interested in personality development. They take the attitude that eating is a problem of learning in the field of personality and realize that far too often the learning is in the wrong direction. Several of them discuss the matter of habitual attitude toward eating not only as it affects and is affected by the child's nutrition, but as it affects and is affected by his nervous system, his

psychological development, his mental hygiene, his personality. Blanton and Blanton (6) take a very definite stand on the relation of eating habits to personality and say that "the early feeding response is fairly indicative of the type of general response to be expected of the child in most of his activities, and it is one of the earliest clues to his personality type and to his type of original endowment. The child may be studied at this earliest stage with a view to modifying as much as is necessary and possible his general temperament." They believe that the eating situation is a good training field for adjustment in other life situations and even go so far as to say that "the way in which he (the child) learns to accept his diet constitutes the establishment of one of the patterns of behavior which will in later life apply to acts other than eating." Blatz and Bott (8), discussing the personality traits of negativism, desire for attention, desire to domineer as related to eating, say, "The dissension set up over feeding difficulties is in most cases infinitely more serious than the feeding difficulties themselves," and Blatz (7), in his "Study of Eating Habits in a Nursery School," in referring to children who have a high score on motor inhibition and a poor score on urging and those who have a high score on urging and a low score on motor inhibition, remarks that "there seems little doubt that we are here face to face with a significant aspect of personality." Thom (46) throughout his discussion of eating habits in his book for parents on *Everyday Problems of the Everyday Child* lays emphasis on the relation between the child's attack on his food, the de-

velopment of his personality, and his mental health. "Experience has taught us," he says, "that many of the undesirable habits and personality twists, so commonly seen in early adolescence, are closely associated in their beginnings with a failure to master these three fundamental habits—eating, sleeping and elimination, which are so directly connected with the organic life of the child." Several other authors, including especially Aldrich (1), Cameron (10), Cleveland (12), Fenton (19), Faegre and Anderson (18), Chandler (11), Richardson (38), and Roberts (39), recognize that eating habits and personality traits appear to be related. Some of them go so far as to suggest that attitude toward eating is associated with and possibly actually affects personality development. Their judgments are based on clinical or teaching experience.

Very little, however, has been done in the way of accumulating scientific data on the subject. Tilson (48) found, in her group of 63 preschool children who showed problems in eating, that poor eating habits correlated positively with temper tantrums ($r=.12$), with thumb-sucking ($r=.20$), and with fear ($r=.07$), as well as with poor nutrition ($r=.12$). We find studies on what young children should eat, on the extent of eating problems among preschool children (quoted above), and studies of various methods of handling little children so as to develop in them good appetites. There is a study by Langford (30a), described in Foster and Mattson (20), of age norms of development of good eating habits, and one by Blatz (7) of the relationship of various eating habits to age of child. But,

beyond the figures quoted from the study of habit clinic cases by Tilson, the writer has found no experimental or descriptive data reported in the literature in regard to the relationship between eating habits and personality traits.

DISCUSSIONS OF THE PROBLEM OF HOW TO GET CHILDREN TO EAT THE FOOD THAT IS GIVEN THEM

- Aldrich (1), whole book (127) pages)
 Arlitt (3), Chapter V, "Eating Habits"
 Blanton and Blanton (6), Chapter III, "Learning to Eat" (25 pages)
 Cameron (10), Chapter III, "Habits of Eating" (24 pages)
 Bruce (9), Chapter XXV, "The Finicky Child" (10 pages)
 Blatz and Bott (8), Chapter IV, "Want of Appetite and Indigestion" (16 pages)
 Faegre and Anderson (18), Chapter VIII, "Eating Habits" (13 pages)
 Langdon (30), Chapter III, "Eating"
 Richardson (38), Chapter VI, "Refusal to Eat" (18 pages)
 Roberts (40), Chapter on "The Prevalence of Non-Hunger among Children and Some of Its Contributing Factors" (19 pages)
 Thom (46), Chapter IV, "Feeding" (21 pages)
 Waring and Wilker (51), Section called "Eating Behavior"
- A few pages or paragraphs are given to the subject in each of the following books and articles:

Arlitt (2)	McCollum (34)
Baker (5)	Miller (35)
Blatz (7)	Rand, Sweeney, and Vincent (37)
Cleveland (12)	Roberts (39)
Emerson (16)	Rose (41)
Emerson (17)	Smith (43)
Fenton (19)	Thom (45)
Foster and Mattson (20)	<i>Twenty-eighth Yearbook of the</i>
Gesell (22)	<i>National Society for the Study</i>
Hill and Van Alstyne (26)	<i>of Education</i> (49)
Johnson (27)	Walsh and Foote (50)
Lucas (32)	Watson (52)
MacCarthy (33)	Wexberg (53)

III

SUBJECTS USED IN THE STUDY

The data for this study were collected from observation of 69 children two and three years of age who, in the year 1927-1928, attended the Nursery Training School of Boston and the Cambridge Nursery School. The children were between the ages of two years and no months and four years and no months, inclusive. Forty-eight of them were in the Nursery Training School and 21 in the Cambridge Nursery School.

THE NURSERY TRAINING SCHOOL GROUP

The 48 children attending the nursery school of the Nursery Training School comprise nearly the complete list of the children enrolled at the time; a few were left out of the study because of prolonged absence or withdrawal from the school after very short attendance. The school is situated in one of Boston's poorer residential districts, mainly composed of blocks of three- to six-family houses, in the immediate neighborhood of which there are factories, warehouses, and shops. The rents in this neighborhood are low (\$15-\$30 a month), the living-quarters crowded, and there is little play space for the children. The families who send children to the school are, in general, families who maintain themselves without outside financial assistance. In a large majority of the cases the fathers are living and working and supporting their families, giving them the necessities and even some of the comforts of life. They are able and glad to pay, and do pay regularly, the dollar a week which the nursery

school charges for the care of the two- and three-year-olds. Most of the parents of these families were educated in this country, many of them having finished the elementary school, some of them the high school. In every way they are cooperative, eager to learn and to take and act upon suggestions in regard to the care and training of their children.

The children used in this study were all born in the United States. The races and nationalities of their parents were as follows:

American (white)	18
American (Negro)	8
American (Jewish)	2
Irish and Irish-American	10
Canadian-American	2
Italian	2
English-American	1
Canadian	1
German-Canadian	1
German-Irish	1
German-Jewish	1
Adopted (by American white)	1
	<hr/>
	48

In all but three cases both parents spoke English.

The occupations of the fathers (or mothers when they were the breadwinners) were as follows:

Father's occupation:	
Professional	4
Lawyers	2
Teachers	2
Skilled or semi-skilled	19
Unskilled	21
Mother's occupation (when the breadwinner):	
Professional (teaching)	2
Unskilled	1
Adopted by unmarried woman doctor	1
	<hr/>
	48

The general health of most of the children was good. Their weight in relation to the average and the physical defects found by the school's pediatrician are shown in Table 1. In all, 29 children were between 10% below and 15% above average in weight and had no defects or only one major defect or one or two minor defects. Only 4 children were more than 10% below average weight, and one of these had no defect.

TABLE 1
PHYSICAL CONDITION OF THE CHILDREN FROM THE NURSERY
TRAINING SCHOOL OF BOSTON

Defects	Deviation from the average weight for height, age, and sex*					Totals
	More than 10% below	Less than 10% below	Average	Less than 15% above	More than 15% above	
Major:						
Enlarged tonsils	1	11	2	5		19
Enlarged adenoids			1			1
Bad teeth	1	1		1		3
Active rickets	1	1				2
Minor:						
Poor posture	2	5	1	1	1	10
Flat feet	2	2	3	2		9
Pot belly	1	5	3		1	10
Old rickets		2	2	1		5
Bow legs		1		1		1
Knock knees						1
Abnormal penis		1	1			2
Enlarged glands	1	1				2
Eye defect	1					1
Umbilical hernia	1					1
No defects	1	6	2	2		11

*According to the scale used by U. S. Children's Bureau and prepared for them by Robert M. Woodbury, Ph.D.

Twenty-nine were considered to be in good health, 16 in fair health, and only 3 in poor health. They were free from contagious disease when studied.

The children of the Nursery Training School group were of average intelligence. As tested by the Kuhlmann (29) revision of the Binet-Simon tests, their IQ's ranged from 63 to 132, the mode being 110-119 and the mean 103.2. As tested by the Lincoln Hollow Square Formboard Performance Test (15, 31), their PQ's ranged from 65 to 253, the mode being 90-99 and the mean 118.4.

THE CAMBRIDGE NURSERY SCHOOL GROUP

Twenty-one children ranging in ages from two years no months to four years no months who attended the Cambridge Nursery School were included in the study. They all attended the nursery school fairly regularly during the period covered.

The Cambridge Nursery School is composed of two groups of children situated in different parts of the moderately well-to-do residential section of Cambridge. The families from which the children come live in single or double detached houses, or in high-grade apartment houses supplied with all modern conveniences. Most of them live in the neighborhood of the location of the nursery school to which the children go, though a few children are brought from more distant residential sections. The homes are comfortable and usually sufficiently roomy so that the children have their own room to play and sleep in. Outdoor play space for those who live in apartment houses is greatly

limited, however. Many of the families keep one or more servants, some a nursemaid for the children. In a few cases the mother does all the work of the home with the occasional help of a cleaning woman.

The families of the children from this group were all white American. The fathers were all professional men. The occupations of fathers and mothers were as follows:

Father's occupation:		
Professional		18
Doctors	4	
Lawyers	2	
Business	6	
Teachers and Professors	6	
Adopted by a Professor		1
Mother's occupation (when the breadwinner):		
Independent income		1
Adopted by unmarried woman		
with independent income		1
		21

The mothers, as well as the fathers, were well educated, a large proportion being college graduates.

The general health of the children was good. Their weight in relation to the average and the physical defects found by the school's pediatrician are shown in Table 2. Fifteen children were between 10% below and 15% above average in weight. Two children were more than 10% below average weight. Fifteen children were considered to be in good health, 4 in fair health, and 2 in poor health.

The children were above average intelligence. As tested by the Kuhlmann Revision of the Binet-Simon

TABLE 2
PHYSICAL CONDITION OF THE CHILDREN FROM THE CAMBRIDGE
NURSERY SCHOOL

Deviation from the average weight for height, age, and sex						Totals
Defects	More than 10% below	Less than 10% below	Average	Less than 15% above	More than 15% above	
Major:						
Enlarged tonsils		1		1	1	3
Enlarged adenoids				1		1
Minor:						
Poor posture		2	1	1		4
Flat feet	1			1		2
Pot belly				1		1
Old rickets		1	1			2
Knock knees				1		1
Enlarged glands		1		1		2
Slight heart murmur		1	1			2
Possible polyglandular problem				1		1
No defects	1	3	1	2	3	10

tests, their IQ's range from 104 to 153, the mode being 120-129 and the mean 126.09. As tested by the Lincoln Hollow Square Formboard Performance Test their PQ's range from 75 to 400, the mode being 90-109 and the mean 140.04

SUMMARIZING TABLES

The following tables give an accurate description of the whole group of subjects studied.

TABLE 3
AGE* OF THE SUBJECTS OF THE STUDY AT THE BEGINNING OF THE
COLLECTION OF DATA

Children from the Nursery Training School of Boston	
2 years 0 months to 3 years 0 months, inclusive	29
3 years 1 month to 4 years 0 months, inclusive	19
Children from the Cambridge Nursery School	
2 years 0 months to 3 years 0 months, inclusive	8
3 years 1 month to 4 years 0 months, inclusive	13
Whole group	
2 years 0 months to 3 years 0 months, inclusive	37
3 years 1 month to 4 years 0 months, inclusive	32

*Ages are reckoned to the nearest whole month, 16 days or more being counted as an additional month, i.e., 2 years 0 months means any age between 1 year 11 months 16 days and 2 years 15 days.

TABLE 4
SEX OF THE SUBJECTS OF THE STUDY

Children from the Nursery Training School of Boston	
Boys	20
Girls	28
Children from the Cambridge Nursery School	
Boys	12
Girls	9
Whole group	
Boys	32
Girls	37

TABLE 5
RACE AND NATIONALITY OF PARENTS OF CHILDREN STUDIED

American (white)	37
American (Negro)	8
American (Jewish)	2
Irish and Irish-American	10
Canadian-American	2
Italian	2
English-American	1
Canadian	1
German-Canadian	1
German-Irish	1
German-Jewish	1
Adopted (by American white)	3

	69

TABLE 6
OCCUPATION OF FATHER (OR MOTHER IF SHE IS THE BREAD-
WINNER) OF CHILDREN STUDIED

Father's occupation;	
Professional	22
Skilled or semi-skilled	19
Unskilled	21
Adopted by professional man	1
Mother's occupation (when the breadwinner):	
Professional	2
Independent income	1
Unskilled	1
Adopted by unmarried woman doctor	1
Adopted by unmarried woman with independent income	1
	<hr/> 69

TABLE 7
GENERAL HEALTH OF SIXTY-EIGHT OF THE SIXTY-NINE*
CHILDREN

Defects	Deviation from the average weight for height, age, and sex			Totals
	More than 10% below	10% below to 15% above	More than 15% above	
2 major defects		1		1
1 major defect (in 10 cases, enlarged tonsils)		10	1	11
Major and minor defects	3	12		15
3 minor defects		3		3
2 or 1 minor defects	1	15	1	17
No defects	2	16	3	21

Classification according to general health

Poor	Fair	Good	Total
5	19	44	68

*One child was not examined by the doctor. He was of average weight and appeared to be in good health.

TABLE 8
 INTELLIGENCE OF SIXTY-SEVEN OF THE SIXTY-NINE* CHILDREN
 AS TESTED BY THE KUHLMANN-BINET-SIMON TESTS (IQ)
 AND THE LINCOLN HOLLOW SQUARE FORMBOARD
 PERFORMANCE TEST (PQ)

	IQ	PQ
Range		
Lowest	63	65
Highest	153	400
Mode	110-119	90-99
Mean (67 cases)	110.4	125.1
Mean (68 cases, omitting one case below 70)	111.1	126.1
Mean (63 cases, omitting one case below 70 and three cases of 200 or over)	---	118.6

*Two children from the Nursery Training School were not tested because they moved away without leaving address and were lost. All other information needed for the study had been obtained so they were included in it.

IV

DATA COLLECTED

During the year 1927-1928 data were collected concerning the eating habits of the 69 children described in the previous chapter. The data consist of a series of teachers' judgments with respect to each child's condition and progress in four selected problems of behavior, and of teachers' ratings of the children in 31 selected personality traits. Each of the four problems has chiefly to do with one of the four aspects of personality already suggested: the problem of eating with physical development, that of constructiveness with intellectual development, that of anger with the emotions, and that of self-assertion with attitudes. Since the major interest of this study centers around the first of these problems, there will be little discussion of the other three except as they seem to be associated with the problem of eating. The list of personality traits^a used does not pretend to be exhaustive or complete but was planned to include representative traits from the same four aspects of personality. The problems and the traits were selected also because they are factors in the child's personality which may be affected by learning and which are apt to become habitual tendencies in the developing organism.

The following descriptions of what is meant by each of the four problems and 31 traits were prepared by the writer and subscribed to by the various teachers

^aThe list may be found in Table 11.

who did the judging and rating. The descriptions are given because the data are based on subjective opinion and in order to make clear the basis for rating. It will be shown later in the section on statistical analysis that the points of view of the nine raters were fairly homogeneous.

PROBLEM IN EATING

A child who is considered a problem in eating is one who is called a finicky eater.

A finicky eater is (1) a child who habitually (more than half the time—in most cases probably nine times out of ten, and in many cases ten times out of ten) refuses to eat one or more kinds of food which are an important part of a normal wholesome diet; or (2) a child who is habitually extremely slow about eating all or nearly all wholesome food (i.e., eats perhaps one-fourth, or less, of the amount which an average child eats, in twice as much time as an average child); or (3) a child who is habitually extremely irregular in his attack upon his food. A finicky eater is the opposite of a non-finicky eater.

A non-finicky eater is a child who, when well, eats at mealtime at least a small amount of whatever wholesome food is given him, in a manner which would indicate a desire to appease hunger (of a greater or less degree).

PROBLEM IN CONSTRUCTIVENESS

A child who is considered a problem in constructiveness is (1) a child who makes things out of the materials provided in the nursery school, or creates ideas out of his experiences (either as a result of previous suggestion by a teacher or not) much less often the average child of his age (i.e., quantity is abnormally small); or (2) a child whose constructions (in things or ideas) are of a markedly less mature type and of much smaller variety than those of the average child of his age (i.e., quality is abnormally poor); or (3) a child who habitually destroys his own and others' constructions (in things or ideas), not for the sake of finding out how they are made or of remaking them, but wantonly.

PROBLEM IN ANGER

A child who is considered a problem in anger is (1) a child who, when thwarted by things, events, or people, strikes, screams, or throws in anger more frequently than the average child of his age; or (2) a child who has tantrums (excessive screaming, kicking, holding of breath, or stiffening with complete loss of self-control) even occasionally; or (3) a child who sulks in anger, harboring a grudge over a situation.

PROBLEM IN SELF-ASSERTION

A child who is considered a problem in self-assertion is (1) a child who habitually pursues any line of conduct merely in order to get the attention of adults or children; or (2) a child who is habitually disobedient or negative in his reactions, wanting his own way merely for the sake of asserting his own power; or (3) a child who is not happy unless he is leading the group, and does not cooperate in the undertakings of others, or subordinate himself to the leadership of others; or (4) a child who has less regard for the rights of others than the average child of his age; or (5) a child who habitually does not stand up for his own rights; or (6) a child who shows far less than average (for his age) self-expression, self-confidence, desire for attention, tenacity, friendliness, joy in use of power, leadership.

Throughout the study a problem in self-assertion of the sort described under (1), (2), (3), and (4) is called a problem in "plus" (+) self-assertion, and one of the sort described under (5) and (6) is called a problem in "minus" (—) self-assertion.

TRAITS WHICH HAVE TO DO WITH PHYSICAL DEVELOPMENT

General habitual activity means the trait indicated by the following overt behavior: walking, running, jumping, climbing, swinging, skipping, riding, pushing, pulling, throwing, pounding, or doing anything (with or without apparatus) which involves bodily movement.

General health means that condition of physical well-being which, to the teacher, is indicated by a well-nourished appearing body, good color in face, clear skin, lack of running eyes, nose, and ears, bright eyes, eager expression, muscular strength, desire for activity (both mental and physical), few absences for illness, lack of nervous tension.

TRAITS WHICH HAVE TO DO WITH INTELLECTUAL DEVELOPMENT

Quickness to learn means the trait indicated by the speed with which a child forms associations which carry over to the next situation of the same or a similar nature; this speed is judged by the child's overt behavior in the second and succeeding situations.

Curiosity means the trait which is indicated by a child's efforts to find out about things. It is shown in the overt behavior of looking at things, manipulating them, turning them over, feeling of them, striking them, opening them, pulling them to pieces, asking questions about them, experimenting with them in connection with other things and with people. It is also shown in a child's experimenting with people's reactions and with situations which involve people and things.

Reasoning means the trait which is indicated by the following overt behavior: (1) acting in a new situation in an appropriate way as a result of previous experiences in situations which held elements in common with the present situation but which were not the same; (2) drawing simple inferences from observation of situations because of previous experience with similar situations; (3) relating two hitherto unrelated objects or events in logical sequence.

Imagining means the trait which is indicated by the following overt behavior of a child: (1) acting in some degree like another person, creature, or thing and in some way indicating that he is pretending to be that person, creature, or thing; (2) telling stories of things which did not really happen; (3) inventing new ways of using material; (4) drawing pictures or making models of things which are not copies of things he has seen; (5) developing new situations and relationships in play, either when alone or with other children.

Perception means the trait indicated by the following overt behavior: (1) prompt response to sounds, sights, tactile and kinesthetic sensations, tastes, and smells; (2) recognition of similarities and discrimination of differences between sensory stimuli.

Manual skill means the trait indicated by the child's ability to handle tools or material in such a way that they are made to do or become what he desires. It is shown in a child's practical activities, such as washing face and hands, pouring liquid, etc., also in constructive activities such as building, painting, cutting, pasting, stringing beads, etc.

Speech means the trait indicated by the child's use of words as a means of communication; it includes the elements of correctness, construction, fluency, enunciation, and intonation.

Constructive tendencies means the trait indicated by a child's overt behavior of making things out of materials, or ideas out of experiences. It also means the absence of wanton destruction of materials or ideas.

TRAITS WHICH HAVE TO DO WITH EMOTIONAL DEVELOPMENT

Fear means the trait indicated by (1) the overt behavior of withdrawing from things or situations accompanied by a cry or facial expression which indicates that a child is frightened; (2) the overt behavior which indicates what is ordinarily called timidity.

Anger means the trait indicated by (1) the overt behavior of striking, kicking, screaming, throwing, or stiffening, accompanied by a facial expression which would indicate that the emotion of anger is aroused; (2) the overt behavior which is ordinarily called sulking.

Affection means the trait indicated by the overt behavior of (1) patting, stroking, hugging, kissing adults, children, or things, accompanied by a facial expression which would indicate that a child has a fondness for the person or thing so treated; (2) less demonstrative types of affectionate behavior such as a desire to be near a person, or a joyous cry or facial expression when greeting a person, or catching sight of a doll or other toy.

Excitability means the trait indicated by (1) the overt behavior of screaming, talking in a high-pitched voice, catching the breath, jumping up and down, moving hands, feet, or head violently, accompanied by a facial expression which would indicate that a child's feelings are strongly stirred in relation to a situation; (2) quieter behavior indicating strong feeling such as muscular tenseness, exclamations under the breath, etc.

Moodiness means the trait indicated by the child's overt behavior of (1) showing sudden and frequent changes of emotional tone without apparent justifying cause, for instance, sudden changes from happy, joyous, self-expressive behavior to whining or sulking behavior, or vice versa; (2) spending much of the time whining, complaining, pouting, sulking, refusing to take part in activities, accompanied by a facial expression which would indicate that a child is unhappy and that his feelings in regard to a situation are unpleasant ones.

TRAITS WHICH HAVE TO DO WITH HABITUAL ATTITUDES AND SENTIMENTS

Self-Assertion

Self-expression means the trait indicated by the overt behavior of (1) talking freely about experiences; (2) laughing, crying, and in other ways giving vent to feelings; (3) entering easily and wholeheartedly into play alone or in the group; (4) using materials spontaneously for his own ends; (5) acting, in general, like what psychologists call an extrovert.

Self-confidence means the trait indicated by the overt behavior of performing tasks, plays, etc., and undertaking new ones, without hesitation and without help, i.e., behavior which seems to indicate that a child is sure of his own powers.

Desire for attention means the trait indicated by the overt behavior of (1) a child's repeating an act when the previous performance of it has drawn the attention of adults or children to himself, or (2) the performing of a new act for the sole purpose (as far as one can tell) of drawing attention to himself.

Tenacity means the trait indicated by the overt behavior of a child's sticking to a task, or play, or mood, or attitude, in the face of possible distractions. It includes both what would ordinarily be called obstinacy and what would ordinarily be called concentration.

Friendliness means the trait indicated by the overt behavior of (1) a quick, smiling response to the approach of adults or children; (2) behavior and facial expression in the presence of other people which indicate a feeling of pleasure; (3) behavior toward other people which calls forth from them a friendly response.

Joy in use of power means the trait indicated by the overt behavior of (1) repetition of an act or continuation of an activity which is new or difficult and taxes the child's power (physical, mental, emotional, or social), accompanied by a facial expression which indicates a feeling of pleasure or joy in the act; (2) facial expression or bodily movement or words or other sound, coming after the accomplishment of an act, which indicate joy in its performance.

Leadership means the trait indicated by the overt behavior of (1) suggesting, planning, organizing, and directing plays, games, or tasks for a group of children; (2) doing the above in such a way as to make the other children glad to follow.

Self-Control

Regard for the rights of others means the trait indicated by the overt behavior of (1) willingly allowing other children to have their turns with apparatus, toys, or interesting activities; (2) taking one's own share in tasks which are necessary but irksome, such as picking up toys, etc.; (3) refraining from pushing, pulling, shouting, or in other ways getting what one wants regardless of other people's desires.

Regard for authority means the trait indicated by the overt behavior of (1) conforming willingly to the laws governing the school community, and (2) obeying requests made by teachers or parents.

Control of power (bodily) means the trait indicated by the overt behavior of (1) running, jumping, climbing, or performing any other physical activity with skill, i.e., without falling, or knocking into people and things, and also attaining the end to which the activity was intended to lead; (2) controlling urination and defecation; (3) making oneself swallow and not regurgitate food which is distasteful; (4) keeping one's body still at appropriate times, such as nap; (5) manual skill (see description above).

Control of power (emotional) means the trait indicated by the overt behavior of (1) not running away from but gradually approaching a feared object or activity; (2) expressing anger only at appropriate times and in firm but calm ways, not kicking, hitting, or screaming; (3) expressing affection only in facial expression and calm demonstration; (4) not crying when fallen down, etc.; (5) laughing only at appropriate times; (6) avoiding extreme excitement and depression; (7) being independent of adult help in caring for self, in play, etc.

Control of power (intellectual) means the trait indicated by the overt behavior of a child's using his curiosity, reasoning, imagining, perception, manual skill, speech, and constructive tendencies (as described above) to their fullest extent consistent with usefulness to himself and to the other members of the community.

Happiness

Joy means the trait indicated by the overt behavior of smiling, laughing, shouting, singing, talking eagerly, moving the body with abandon, working and playing spontaneously and with interest, repeating activities because they have brought pleasure, etc.

Love of beauty means the trait indicated by the overt behavior of talking about or asking for or showing (by facial expression, poise

and movement of body, muscle tension, or exclamation) a keen interest in music, poetry, flowers, pictures, colors, materials, forms, etc.

Wonder means the trait indicated by the overt behavior of (1) a child's facial expression, muscle tension, or exclamation which would indicate interest, pleasure, and awe in the presence of something which is to him inexplicable; (2) a child's asking eager questions about inexplicable things and pursuing them till no completely explanatory answer is available.

Adjustment means that trait which is indicated by the overt behavior of (1) taking part easily and eagerly in new situations involving people or things; (2) adapting his actions to such new situations wholeheartedly and with singleness of mind.

METHOD OF RECORDING DATA

In November, 1927, records were made for each child between the ages of two years no months and four years no months then attending the Nursery Training School of Boston and the Cambridge Nursery School. The two teachers in charge of each group of children and the writer, after two days' observation, rated each child in each of the 31 personality traits on a five-point rating scale according to the amount of the quality which they believed the child to possess at the time. The three raters made their records independently and without consultation. On the rating scale, three (3) represented the average amount of the quality for children of the given child's age, two (2) less than that amount, one (1) much less, four (4) more than the average amount, and five (5) much more than the average. The three ratings for each trait for each child were averaged and the nearest whole number to the average was the rating used in assembling the data. A record was also made of the condition of each child with respect to the major

problem of eating and each of the other problems. These judgments were arrived at in conference by the two teachers and one observer who knew the children. The parents of all the children were interviewed and records of their statements of the children's behavior at home helped the teachers to make their judgments in regard to the four problems. Judgments of eating habits of the children in the Cambridge Nursery School had necessarily to depend to a great extent on parents' statements for the only eating situation in the school is mid-morning lunch.

It is obvious that both the ratings and the judgments were arrived at subjectively. They were opinions based on the overt behavior of a given child compared with a subjective standard of what is average behavior for children of that age. This subjective standard had been set up through experience with and intimate knowledge of many children of the same age aided by a background of knowledge regarding objective standards of physical and mental measurement which is helpful in stabilizing subjective judgments of behavior. Judgments in regard to the eating habits of children in the Nursery Training School were made more objective by the aid of the school's record of what and how much each child eats each day with notes as to any unusual reason for his not eating, such as illness or emotional upset. The raters agreed to consider each child's behavior in relation to all the activities of the nursery-school day so that in rating traits undue weight would not be given to behavior at meal-time or any other special occasion.

One month later new records were made for each child who had been considered a problem in any of the four respects of eating, constructiveness, anger, or self-assertion. The traits were rated as before without consulting the previous record. The problems were judged cooperatively as before and any change for better or worse noted after consulting the previous record. Records were made in this way each succeeding month for each child who remained a problem in any of the four ways, and a final record was made for each child no longer considered a problem. This was continued for six months. A few new children who were admitted to the nursery schools during this period were added. In all, 69 children were studied. In the cases where the child was not considered a problem in any of the four respects only one record was made. In the few cases where the child remained a problem throughout the period six records were made.

GROUPING OF CHILDREN WITH RESPECT TO PROBLEM OF EATING

The 69 children included in the study were classified on the basis of the first recording as finicky or non-finicky eaters according to the description of "eating problem" as given above. Table 9 shows this classification for the whole group and also according to school, age, and sex. The most striking difference is found in the proportion of finicky eaters in the Nursery Training School, 43.7%, as compared with the proportion found in the Cambridge Nursery School, 14.2%. This might in some measure be accounted for by the

TABLE 9
SCHOOL, AGE, AND SEX OF FINICKY AND NON-FINICKY EATERS
AT FIRST RECORDING FOR EACH CHILD

	School		Age						Sex				Whole group	
			2 y. 0 m.		3 y. 0 m.		4 y. 0 m.		5 y. 1 m.		Girls		Boys	
	N.T.S. No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Finicky	21	43.7	3	14.2	13	35.1	11	34.3	14	37.8	10	31.2	24	54.7
Non-finicky	27	56.3	18	85.5	24	64.9	21	65.7	23	62.2	22	58.8	45	65.5
Totals	48	100	21	100	37	100	32	100	37	100	32	100	69	100

fact that dinner is not served in the Cambridge Nursery School so our only evidence in regard to eating habits is mid-morning lunch and parents' statements. Thus milder forms of finickiness may have been overlooked. The table shows that slightly more than one-third of the group were finicky at the beginning of the study, and that age and sex do not seem to be important factors in the problem.

The children classified as finicky eaters at the first recording were studied each succeeding month and reclassified as finicky or non-finicky. The final records of 13 children showed that they had become non-finicky. These records were added to the original group of 45 non-finicky eaters, making a total non-finicky group of 58. The records of 8 of the original finicky eaters showed at some recording during the months when they were studied that there had been a decided improvement in their eating habits but that they must still be classified as finicky according to our description of what constitutes a finicky eater. In other words, these children had changed from severe eating problems to mild eating problems. The records of these 8 children at the time when they were recorded as slightly finicky were added to the original group of 24 finicky eaters making a total finicky group of 32. These subsequent recordings on some of the 69 children were used as additional cases in assembling the data on the ground that for the purposes of this study a child whose eating habits have changed markedly, whether the change is accompanied or unaccompanied by a change in personality traits, makes a new case

from the point of view of eating habits as associated with personality traits. The total group of non-finicky eaters is weighted with children who were non-finicky at the first recording, the finicky group is weighted with children who were slightly finicky eaters. Table 10 shows the distribution of the 90 recordings which were selected for use in assembling the data.

In order to study the more severe types of eating problem represented in the study there have been selected from the group of finicky eaters a group of 10 recordings which are called the "exaggeratedly finicky eaters." These 10 are the first recordings on the children who showed the worst eating problems of the group and who would be called by ordinary standards very poor eaters. None of the problems, however, were as severe as the extreme types known to exist among young children, for instance, those of neurotic vomiting.

TABLE 10
DISTRIBUTION AMONG THE SIXTY-NINE CHILDREN OF THE NINETY
SELECTED RECORDINGS AND CLASSIFICATION OF EACH

No. of children	No. of recordings used per child	Classification of recordings	No. of recordings		
			Finicky	Non-finicky	Total
45	1	Non-finicky only	0	45	45
9	1	Finicky only	9*	0	9
7	2	1 finicky and 1 non-finicky	7	7	14
2	2	2 finicky only	4*	0	4
6	3	2 finicky and 1 non-finicky	12	6	18
69		Totals	32	58	90

*These children did not become non-finicky throughout the period of study, either because they were unusually stubborn cases or because they were taken on as new cases toward the end of the period, or because they moved away and left the nursery school during the period.

V

STATISTICAL ANALYSIS OF DATA

As already explained, 90 recordings of 69 two- and three-year-old children were selected as cases for study of the association of finicky or non-finicky eating with 31 personality traits. Of the 90 cases, 32 were finicky and 58 were non-finicky. A group of 10 exaggeratedly finicky eaters were selected from the 32 finicky in order to give a more complete picture of the problem.

RELATION OF EATING HABITS TO PERSONALITY TRAITS IN THE WHOLE GROUP OF CASES

Each child was given at each recording a rating on a five-point scale in each of the personality traits. The rating was the average of ratings made by three observers. The numbers of children in each group whose rating fell in each grade of the scale and the average rating of each group were determined for each trait. Table 11 gives the average ratings and shows the differences between finicky and non-finicky eaters in the 31 traits. The finicky eaters were rated lower in general health than the non-finicky; higher in perception, anger, excitability, moodiness, self-expression, self-confidence, desire for attention, joy in use of power, leadership; lower in regard for the rights of others, regard for authority, emotional and intellectual control, and joy; higher in love of beauty; lower in adjustment.

In order to determine how significant these differences are, the critical ratio of the difference between

TABLE 11
AVERAGE RATING FOR GROUPS OF NON-FINICKY, FINICKY, AND
EXAGGERATEDLY FINICKY EATERS IN EACH OF
THIRTY-ONE PERSONALITY TRAITS

Personality traits	Number of cases→ 45 Non-finicky eaters	32 Finicky eaters	10 Exaggeratedly finicky eaters
I Body			
1. General habitual activity	2.913	3.00	3.2
2. General health	3.068	2.718	2.7
II Intellectual habits			
1. Quickness to learn	3.137	3.187	3.3
2. Curiosity	3.137	3.187	3.4
3. Reasoning	3.172	3.093	3.3
4. Imagining	3.068	3.125	3.3
5. Perception	3.206	3.343	3.6
6. Manual skill	2.982	3.031	3.1
7. Speech	3.051	2.906	3.1
8. Constructive tendencies	2.844	2.937	3.0
III Emotional habits			
1. Fear	2.827	2.843	2.9
2. Anger	2.965	3.187	3.4
3. Affection	3.051	3.093	3.2
4. Excitability	3.034	3.250	3.5
5. Moodiness	2.844	3.187	3.1
IV Habitual attitudes and sentiments			
1. Self-assertion			
a. Self-expression	3.017	3.375	3.6
b. Self-confidence	3.051	3.156	3.2
c. Desire for attention	3.120	3.343	3.6
d. Tenacity	3.224	3.281	3.4
e. Friendliness	3.241	3.218	3.3
f. Joy in use of power	3.189	3.218	3.5
g. Leadership	2.758	3.000	3.2
2. Self-control			
a. Regard for rights of others	2.948	2.656	2.4
b. Regard for authority	2.982	2.718	2.7
c. Control of power			
bodily	2.982	2.906	3.1
emotional	2.827	2.500	2.3
intellectual	2.965	2.781	2.9
3. Happiness			
a. Joy	3.034	2.625	3.1
b. Love of beauty	3.120	3.250	3.5
c. Wonder	3.189	3.218	3.3
d. Adjustment	3.068	2.750	2.9

TABLE 12

CRITICAL RATIOS FOR DIFFERENCE BETWEEN AVERAGE RATINGS OF
NON-FINICKY AND FINICKY GROUPS IN THE FIFTIEN
TRAITS WHERE THE DIFFERENCE IS GREATEST

Trait	Critical ratio
General health	2.570
Perception	1.955
Speech	.9972
Anger	1.437
Excitability	1.561
Moodiness	2.593
Self-expression	2.600
Self-confidence	.7037
Desire for attention	1.735
Joy in use of power	.2422
Leadership	1.493
Regard for rights of others	1.417
Regard for authority	1.791
Emotional control	2.290
Intellectual control	1.528
Joy	1.531
Love of beauty	1.090
Adjustment	2.197

the non-finicky and the finicky group was found in the 18 traits where the difference in the averages was largest. Table 12 gives the critical ratios for these 18 traits. According to Garrett (21), a critical ratio of 1.40 means that there are 92 chances in a hundred that the difference between the two measures is greater than zero, if it is 2.00 there are 98 chances in a hundred that it is greater than zero. This would mean that a true difference almost certainly exists between finicky and non-finicky eaters in five of the traits, general health, moodiness, self-expression, emotional control, and adjustment, and that a true difference probably exists in eight other traits, anger, excitability, desire for attention, leadership, regard for rights of others, regard for authority, intellectual control, and joy. The

list which follows shows which of these 13 traits were rated lower for finicky than for non-finicky eaters and which were rated higher.

Lower	Higher
General health	Anger
Regard for the rights of others	Excitability
Regard for authority	Moodiness
Emotional control	Self-expression
Intellectual control	Desire for attention
Joy	Leadership
Adjustment	

Because the data as to the occurrence of these traits in the selected groups are based on subjective ratings made by different observers and therefore may not be reliable, the coefficients of correlation were found between the ratings made by each pair of those who rated the same children for the four traits showing the most significant differences between the finicky and non-finicky groups. These four traits are general health, moodiness, self-expression, and emotional control. There were nine persons rating, two teachers in each of four groups and the writer as the third rater for all the children. These nine raters have been designated as A, H, E, B, Aus, Ea, L, C, and Lo according to the first letter or letters of their last names. Table 13 gives the coefficients of correlation. It would seem to indicate that in at least three of the traits the ratings were fairly reliable. The average of the averages for all the correlations is $r=.6024$, $P.E.=.0643$. By using Spearman's "prophecy" formula the writer finds that the effect of trebling the number of raters would be to

make the theoretical approximate $r=.82$. This seems to show a sufficiently good reliability for the rating scale. We may perhaps assume that in the traits where the differences between the finicky and non-finicky groups are less than they are for the four where the difference is most significant, the "r" of the raters with each other would be proportionately high.

The above data may therefore be considered fairly indicative of the true relation between certain personality traits and finickiness or non-finickiness in eating. Finicky eaters among two- and three-year-old children seem to have less general health, to be more emotional and less controlled in emotional expression, more self-assertive and self-expressive, less well adjusted and less happy than non-finicky eaters.

COMPARISON OF WEIGHT AND IQ OF THE GROUPS OF FINICKY EATERS AND NON-FINICKY EATERS

Table 14 shows that a large majority of each group was normal in weight. Few of the finicky eaters were below normal in weight, and there are some non-finicky eaters who are below normal. This would seem to indicate that eating habits and weight for height, age, and sex are not closely associated.

Table 15 shows that the average intelligence of the three groups of children is normal or above. Finickiness apparently does not vary much with IQ. The difference of nearly 9 points in IQ between the finicky and non-finicky groups may be accounted for by the fact that so few (3 out of 21) of the Cambridge Nursery School children (where IQ's were generally high)

TABLE 14
DEVIATION FROM THE AVERAGE WEIGHT FOR HEIGHT, AGE, AND
SEX OF NON-FINICKY, FINICKY, AND EXAGGERATEDLY
FINICKY EATERS

	More than 10% below average weight	From 10% below to 15% above average weight	More than 15% above average weight	Totals
Non-finicky	4	49	5	58
Finicky	4	28	0	32
Exaggeratedly finicky	2	8	0	10

TABLE 15
AVERAGE INTELLIGENCE QUOTIENT AND AVERAGE PERFORMANCE
QUOTIENT FOR THE THREE GROUPS

	Non-finicky 57 cases*	Finicky 31 cases*	Exaggeratedly finicky—10 cases
IQ (average)	111.05	102.7†	110.0
PQ (average)	124.4	119.5	117.8

*One child in each of the non-finicky and finicky groups was not tested.

†The IQ for 21 cases of finicky eaters (omitting the second recording of the 8 children who were used twice as finicky) was 102.6.

were considered finicky. Only the more pronounced feeding problems in the Cambridge Nursery School groups were considered finicky because questioning the parents failed to bring out any of the milder forms. Two of the three finicky eaters in the Cambridge Nursery School group were included in the exaggeratedly finicky group. In other words, the opportunity for the nursery-school teachers to watch the children at the Nursery Training School during the dinner hour revealed a larger proportion of finicky eaters in these groups than the statements of the parents of the Cambridge Nursery School children revealed there, but

TABLE 16
NUMBER AND PERCENTAGE OF CASES IN EACH GROUP IN WHICH THE THREE OTHER PROBLEMS DO NOT APPEAR OR APPEAR ALONE OR COMBINED WITH OTHERS

	Number of cases			Percentages of cases		
	Non-ficky	Ficky	Exaggeratedly finicky	Non-ficky	Ficky	Exaggeratedly finicky
Constructiveness only	0	5	0	0.0	9.4	0
Anger only	2	0	0	3.4	0	0
Self-assertion only (plus)	4	3	1	6.9	9.4	10
Self-assertion only (minus)	6	2	1	10.4	6.2	10
Constructiveness and anger	0	1	1	0	3.1	10
Constructiveness and self-assertion (plus)	2	3	2	3.4	9.4	20
Constructiveness and self-assertion (minus)	7	5	1	12.1	9.4	10
Anger and self-assertion (plus)	4	10	3	6.9	31.2	30
Anger and self-assertion (minus)	1	0	0	1.7	0	0
All three (self-assertion plus)	5	3	1	8.6	9.4	10
All three (self-assertion minus)	0	1	0	0	3.1	0
None	27	5	0	46.6	9.4	0
Totals	58	32	10	100.0	100.0	100

it also revealed a smaller proportion of exaggeratedly finicky eaters as compared to the total number of finicky eaters than in the Cambridge Nursery School groups.

RELATION OF PROBLEM OF EATING TO PROBLEMS OF CONSTRUCTIVENESS, ANGER, AND SELF-ASSERTION

Data based on the combined judgments of three observers were also recorded for the 90 cases in regard to three other problems in child development beside that of eating habits. Table 16 shows the relation of these to eating habits. A much larger percentage (46.6%) of the group of non-finicky eaters were no problem in the other three respects than of the finicky eaters (9.4%) or the exaggeratedly finicky eaters (0). The problem of plus self-assertion appears to be associated with finicky eating in at least half of the cases (56.2%).

RELATION OF EATING HABITS TO PERSONALITY TRAITS IN A GROUP OF THIRTEEN CHILDREN WHO WERE FINICKY EATERS AND BECAME NON-FINICKY

In order to find out what personality changes came about in the children whose eating habits improved, the 13 children who were originally classified as finicky eaters and were later classified as non-finicky eaters were selected for special study. The case histories of some of these children will be found in the appendix. Table 17 gives in parallel columns for comparison the average ratings for this group in the 31 personality traits at the time they were finicky and at the time they

TABLE 17
 AVERAGE RATINGS IN THIRTY-ONE PERSONALITY TRAITS OF THE
 THIRTEEN CHILDREN WHO WERE FINICKY EATERS AND
 BECAME NON-FINICKY EATERS AT THE TIMES
 THEY WERE SO CLASSIFIED

	Finicky	Non- finicky
I Body		
1. General habitual activity	3.000	3.000
2. General health	2.615	2.923
II Intellectual habits		
1. Quickness to learn	3.153	3.230
2. Curiosity	3.230	3.230
3. Reasoning	3.153	3.076
4. Imagining	3.153	3.153
5. Perception	3.307	3.384
6. Manual skill	3.076	3.076
7. Speech	2.769	2.923
8. Constructive tendencies	2.923	3.076
III Emotional habits		
1. Fear	2.923	3.076
2. Anger	3.307	3.000
3. Affection	3.000	3.230
4. Excitability	3.230	3.230
5. Moodiness	3.153	3.076
IV Habitual attitudes and sentiments		
1. Self-assertion		
<i>a.</i> Self-expression	3.307	3.153
<i>b.</i> Self-confidence	3.000	3.076
<i>c.</i> Desire for attention	3.307	3.153
<i>d.</i> Tenacity	3.153	3.307
<i>e.</i> Friendliness	3.153	3.076
<i>f.</i> Joy in use of power	3.230	3.307
<i>g.</i> Leadership	3.000	3.000
2. Self-control		
<i>a.</i> Regard for rights of others	2.615	3.000
<i>b.</i> Regard for authority	2.615	3.076
<i>c.</i> Control of power		
bodily	2.846	2.923
emotional	2.538	2.769
intellectual	2.615	3.000
3. Happiness		
<i>a.</i> Joy	2.923	3.000
<i>b.</i> Love of beauty	3.384	3.153
<i>c.</i> Wonder	3.307	3.307
<i>d.</i> Adjustment	2.615	2.846

TABLE 18

CRITICAL RATIOS FOR DIFFERENCE BETWEEN AVERAGE RATINGS
OF GROUP OF THIRTEEN FINICKY EATERS WHO BECAME
NON-FINICKY EATERS AT THE TIMES THEY WERE SO
CLASSIFIED, FOR FIVE SELECTED TRAITS

Trait	Critical ratio
Self-expression	.5655
Regard for rights of others	2.833
Regard for authority	2.106
Emotional control	1.272
Adjustment	1.151

were non-finicky. Table 18 gives the critical ratios for the differences in the average ratings for this group in five selected traits. These critical ratios would seem to indicate that for the traits where the difference is three-tenths of a point or more it is probably significant.

The following list shows in which traits this group of children was lower or higher when finicky than when non-finicky.

Lower	Higher
General health*	Anger*
Speech	Self-expression
Constructive tendencies	Desire for attention
Fear	Love of beauty
Affection	
Tenacity	
Regard for the rights of others*	
Regard for authority*	
Emotional control	
Intellectual control*	
Adjustment	

*Difference probably significant

A comparison of this list with a similar list for the whole group of cases, given earlier in this section, shows that both the whole group of finicky eaters (32)

and non-finicky eaters (58) and the group of 13 who were finicky and became non-finicky show probably significantly lower ratings for finicky than for non-finicky eaters in general health, regard for the rights of others, regard for authority, and intellectual control. Both groups show probably significantly higher ratings for finicky than for non-finicky eaters in anger. In the other traits in which a significant difference for the whole group was found, a difference (though probably not a significant one) was found in the same direction for the special group of 13 children in emotional control, adjustment, self-expression, and desire for attention. A group of 13 subjects is, of course, extremely small for statistical analysis. The results are necessarily very unreliable. Such a group may, however, indicate a trend.

Table 19 shows the numbers and percentages of children in the special group of 13 who were considered problems in constructiveness, anger, and self-assertion at the times they were classified as finicky and non-finicky. All 13 children were problems in at least one of the above three respects, and 11 in more than one of the three, at the time that they were finicky. When they became non-finicky, 9 of the children were no problem in any of the other three respects. The case histories show that the others (4 children) although still considered problems in various respects had improved greatly in these respects as their eating habits improved.

It appears, then, that the children who changed during the months covered by the study from being finicky

TABLE 19

NUMBERS AND PERCENTAGES OF CASES OF GROUP OF THIRTEEN FINICKY EATERS WHO BECAME NON-FINICKY IN WHICH THE THREE OTHER PROBLEMS DO NOT APPEAR, OR APPEAR ALONE OR COMBINED WITH OTHERS

Problems	Number of cases		Percentages of cases	
	Non-finicky	Finicky	Non-finicky	Finicky
Constructiveness only	0	0	0	0
Anger only	0	0	0	0
Self-assertion (plus) only	2	1	15.4	7.7
Self-assertion (minus) only	1	1	7.7	7.7
Constructiveness and anger	0	0	0	0
Constructiveness and self-assertion (plus)	0	0	0	0
Constructiveness and self-assertion (minus)	0	1	0	23.1
Anger and self-assertion (plus)	1	6	7.7	46.1
Anger and self-assertion (minus)	0	0	0	0
All three (self-assertion plus)	0	1	0	7.7
All three (self-assertion minus)	0	1	0	7.7
None	9	0	69.2	0
Totals	13	11	100.0	100.0

to non-finicky eaters changed also in certain personality traits. Though the handling of the eating situation may have had some influence on these traits, the change can by no means be wholly attributed to it, for, as at all times in these two nursery schools, every effort was made throughout the period to deal with all personality problems in whatever situation they may have appeared. Possible relationships between personality traits and eating habits will be discussed further in the next section.

VI

POSSIBLE RELATION BETWEEN THE GUIDANCE OF EATING HABITS AND PERSONALITY DEVELOPMENT

In the previous chapter it has been shown that in a group of 69 nursery-school children certain personality traits were found to be associated with finickiness in eating. What does this signify for preschool education? Does it justify a belief that the method of handling the eating situation may have an effect upon behavior at mealtime which is indicative of specific personality traits, or that it may have an effect upon generalized personality traits? Or does it mean that certain personality traits in a child bring about finicky eating? For those who are guiding the development of young children these are questions of great interest.

The general method of handling the eating situation at the two nursery schools attended by the children used in this study is to stimulate appetite by good general hygiene, to set the stage for a pleasant atmosphere at mealtime, to give the child plenty of time and occasionally remind him to eat, to take the food away when mealtime is over, and, lastly, not to force him to eat or substitute a food he likes for one he dislikes. It is a pleasant, cheerful, matter-of-fact approach. To the child who eats what is difficult for him there is an extra smile and word of approval. This is much the same as the method advocated by most of the authors already referred to. It is also the method suggested to the par-

ents by the teachers in these nursery schools when seeking their cooperation in the matter of their children's eating habits. The method is one which must be consistently carried out at home as well as in school if a child is to become a non-finicky eater.

Such handling of the eating situation is also a good method of guiding problems of behavior associated with eating which are indicative of the personality traits that the statistical study shows are associated in greater degree with finicky eating than with non-finicky. The more significant of these traits can be summed up under the general characteristics of unduly exaggerated self-assertion and undue and uncontrolled emotional expression. We have no way of knowing whether either of these traits is cause or effect of finicky eating or whether some other unknown concomitant factor is the cause of both the finicky eating and the attitude or emotional state. To those who have occasion to watch such situations it often seems that refusal of food may be a way of gaining the attention of adults, or that it may be a way of expressing oneself, of being somebody, of making one's power felt, of gaining recognition, of defying authority. On the other hand, it may be the result of a highly charged emotional situation, induced in some other connection but carried over because of the child's poor emotional control. If either of these should be, perchance, the cause of refusal of food, the procedure outlined above would be good treatment for the cause of the refusal as well as for the refusal itself. The same is true of the other traits which, according to our figures, are significantly associated with finickiness.

If, on the other hand, food finickiness were the cause and not the result of these personality traits, the treatment which will correct it will, of course, help to correct them also. If these traits are neither cause nor result of finickiness, but are caused by some unknown factor which also causes the finickiness, the treatment which is successful treatment for both the finickiness and the associated trait may have an effect upon the unknown concomitant factor as well.

The personality traits that were found to be exaggerated in the finicky eaters may, when associated with the eating situation, be guided in good directions if meals are handled according to the method described above. Finicky or non-finicky eating and these traits, like many others, may become in time habitual tendencies. It does not require many occasions of keen-edged hunger appeased by oatmeal to establish a habit of eating oatmeal gladly. It does not take many occasions when the child's undue self-assertion expressed through refusal of food is met by a neutral uninterested attitude to establish the habit of not asserting oneself in that particular way. There do not need to be many occasions when the child feels an increase of power in conquering a difficulty (such as eating disliked food) to make joy in that act and the act itself a habit. When these traits are habitually manifested in the eating situation and thus become associated with it, it seems fairly clear that they may be affected by or affect the attitude toward food.

What is not clear is that the eating situation may affect a generalized trait or that a generalized trait

may affect the eating situation. The first question here involved is whether personality traits may become to any extent generalized. Are some children generally more self-assertive than others? Is there such a thing as a general attitude of emotional control? Are we speaking truthfully when we say that a certain child has a better general power of adjustment than another child, or that he is in general a more joyous child than another? These are common ways of describing children but they may be mistaken ways. We habitually talk and think of children and adults as having personality traits which are generalized. "That man is dishonest." We assume that if he has acted dishonestly in one situation he will probably do so in another. Are we justified in making such an assumption? Many present-day writers, among them Bagley (4), Judd (28), Rugg (42), and Ogden (36), agree that in recent years the pendulum of educational thought has swung too far in the direction of emphasis on the specificity of all learning and behavior. Starch (44) says that the fundamental problem is not "does training transfer?" but rather "to what extent and how does it transfer?" Thorndike's (47) concept of "identical elements" indicates his belief in the possibility of some generalization. He says, "The general theory of identical elements--that one ability is improved by the exercise of another only when the neurones whose action the former represents are actually altered in the course of the exercise of the latter--is sound, and is useful in guiding thought. However, so little is known about which neurones are concerned in any ability that this general

theory does not carry us far." He believes that some of the particularized bonds are of very widespread value and says, "His past life provides every man with a set of attitudes or mental 'sets' in response to the mere fact that a statement is made regardless of what the statement is, to the mere asking of any question, to the mere presence of a conflict of interests, etc."

The most important recent investigations in the field of specificity and generalization of personality traits are those which Hartshorne and May (24, 25) have conducted under the auspices of the Character Education Inquiry of Teachers College, Columbia University. These authors themselves seem to feel that the results of their studies point toward specificity. In *Studies in Service* (p. 278) they say, "As in the case of deception, no evidence of the existence of a general trait of selfishness or unselfishness was found." The results of their various investigations would, however, seem to the writer to show considerable evidence that some generalization of the traits exists.

These authors give correlations between various tests for certain traits.⁴ The average intercorrelations between different tests for each of the traits studied are .256, .201, .239, and .16. Although these are low, they are positive. This would seem to mean that the chances that the child who deceives (or is of service or is self-controlled) in one situation will deceive (or be of service or be self-controlled) in another are greater than that he will not. Therefore, the figures seem to indi-

⁴See *Studies in Deceit* (24), pp. 380-384, and *Studies in Service and Self-Control* (25), pp. 111, 332, and 339.

cate some measure of generalization, not absolute specificity. It would be valuable to increase the number of types of tests for each trait, as Hartshorne and May themselves suggest, to see how such increase would affect the correlations.

In their secondary studies, Hartshorne and May (24, 25) show that in all three traits (deceit, service, and self-control) certain groups of children (classified by home, community, school, religious, or national background) have a greater tendency than others to be deceitful, to be of service, and to be self-controlled. This might be considered another bit of evidence that somewhat generalized traits exist. If children coming from homes or communities of high economic and educational standard are less likely to deceive in deception tests in the classroom than those from homes of poor standard, it seems clear that in the children of the first group there is a generalized tendency toward honest conduct which has carried over from specific out-of-school situations to specific in-school situations.

The scores of true validity for the tests of deceit, service, and self-control reported by these authors and the correlations between the total scores on the tests and the children's reputation scores for the different traits seem to add further evidence of generalization. The criteria used for true validity were the opinions of teachers, the opinions of other children, and, in the case of one of the deception tests, the opinion of each child of himself. Reputation was established by different methods for the different traits. It was based on teachers' records, judgments, and ratings and was

largely a matter of subjective opinion, not of objective data. The opinions of teachers and children which were used in these two ways were developed from a knowledge of each child's behavior in many types of specific situations which had or had not called forth the sort of conduct which the judges considered indicative of the trait under consideration. This would seem to mean that in the minds of the teachers or other raters the traits were generalized. The scores and correlations given by Hartshorne and May are as follows:

True validity		<i>r</i> of tests with reputation	
Deception	.40 (<i>Studies in Deceit</i> , Bk. II, p. 117)	(not given)	
Service	.73 (<i>Studies in Service</i> , p. 112)	.61	(<i>Studies in Service</i> , p. 107)
Persistence	.52 (<i>Studies in Self-Control</i> , p. 333)	.23	(<i>Studies in Self-Control</i> , p. 331)
Inhibition	.80 (<i>Studies in Self-Control</i> , p. 340)	.40	(<i>Studies in Self-Control</i> , p. 336)

These show that the subjective opinions of teachers and other children in regard to a child's possession of what appears to be a generalized trait correlate rather favorably with the results of the tests of specific acts.

Thus, in the Hartshorne and May studies (24, 25) three sorts of data are to be found which the writer considers evidence that the traits of deceit, service, and self-control were to a certain extent generalized in the children studied. If any generalization of these traits

exists, we may fairly argue that other traits may also be to some extent generalized. It is therefore possible that there is some generalization of the personality traits which, according to the study presented in this paper, have been shown to be associated with finicky eating.

The second question involved in the possibility that the eating situation may affect or be affected by a generalized trait is "how do traits become generalized?" Hartshorne and May's discussion throws light on this question also. They suggest that honest, or serviceable, or self-controlled conduct must be developed in school children through learning in specific situations, plus explanations and discussions. They appear to believe that, if the specific situations are of various types and the carry-over from one to another is carefully pointed out, a tendency toward a certain kind of conduct can be developed. "There is no doubt but that changes in social conduct can be produced" (25, p. 274). "There is abundant evidence (in the studies) that children have been acquiring habits which are important for character" (25, p. 453). The writer agrees with these authors that tendencies and attitudes must be taught through specific situations, but believes that the subconscious carry-over from one to another is greater than these authors are willing to admit, and that learning is to some extent generalized, whether it be through identical elements or through use of the same neurones, as Thorndike (47) points out. A situation in which there is an opportunity for similar behavior to that shown in a previous situation seems to call out that be-

havior more frequently than not. As behavior in one situation is modified through learning, there seems to be a tendency for similar behavior in another situation to be modified also.

The foregoing study of finicky and non-finicky eating in relation to certain personality traits gives us no evidence for generalization of these traits.⁵ It also throws no light on the question of "how do traits become generalized?" Experience with finicky and non-finicky eaters and with young children in general, however, leads the writer to believe that there is some generalization in the development of personality traits, such as greater or less self-assertion. This generalization of traits is not like the old notion of "faculties," entities which were supposed to be innate in personality and to operate automatically in every situation which called for their action. It is the kind of generalization which Hartshorne and May's studies seem partly to prove. It is what might be called "habitual tendency." If a human being learns to behave habitually in a certain way in one specific kind of situation, he is more, rather than less, likely to behave in a similar way in somewhat similar situations or in a situation where the outcome of similar behavior will bring similar satisfactions. In other words, the child who gets much attention and therefore much satisfaction out of refusing to eat will be more likely to refuse to do other

⁵As set forth in Sections 4 and 5, nine people rated the children in the personality traits. These raters were thinking of the traits in generalized terms. The average correlations of their ratings with each other for four traits was .6024, the theoretical approximate r being .82. This might be considered very slight evidence that these traits are generalized.

things which authority wishes him to do in order to get the same satisfaction. To the extent to which this occurs, behavior becomes generalized, and we say with truth that the child is negativistic, or too self-assertive, or stubborn. He has developed an habitual tendency, a personality trait to some extent generalized.

The way to change such a tendency is by withholding the attention in each specific situation. Doing this only in the eating situation would do much to change the tendency in the eating situation but would have little apparent effect on refusal in other situations. Yet, if anyone who has tried this method of correcting the habit of refusing food for the sake of the attention such behavior brings were to shift his policy to withdrawing attention in all situations where refusal to do what authority suggests brings attention, he would find that the tendency to refuse in any situation changes more readily than when one specific situation is attacked alone. Such an experience (it is one which comes to all those who are most successful in handling behavior problems) seems to be evidence of some sort of carry-over, some kind of generalization. Perhaps it is fairly easy to believe that carry-over in the development of personality traits can be made by adults and older children through the medium of conscious thought and effort, what Colvin (13) calls "raising the habit to be formed to the plane of ideas." The discussions in this paper, however, refer to the generalization of traits in very young children where the element of conscious thought and forethought enters in very little if at all. Yet in the nursery school we constantly

see a general change in attitude and behavior. When refusal to eat brings no satisfying attention, the spread of refusals in other situations appears to become less wide, and other habitual refusals are more easily changed. This might be accounted for by those who argue for specificity by considering the acts so affected as specific refusal-attention-getting situations. They are specific to that extent, but the refusal-attention-getting situation is far more general than the refusal-to-eat-attention-getting situation. The writer believes that learning in every specific act of a little child's life has some carry-over value to other acts and so affects in greater or less degree a generalized personality trait.

The present study proves nothing as to transfer, proves nothing as to generalization of traits, it shows only that in this particular group of children the children who were finicky eaters, according to the writer's description, were probably significantly different from the non-finicky eaters in thirteen personality traits. Suggestions as to other possible relationships between eating habits and personality development are based on the writer's general knowledge and experience. Case histories which will be found in the appendix will help to illustrate some of the tendencies which the writer believes exist. The statistical study piques our curiosity as to the possibilities of cause and effect. Further studies might reveal a causal relationship between eating habits and personality development.

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VII

CONCLUSIONS

1. Certain authorities in the field of preschool education and child guidance believe that eating habits are significant in personality development.

2. The writer's study of 69 nursery-school children shows that the finicky eaters were rated probably significantly higher in six personality traits and probably significantly lower in seven personality traits than the non-finicky eaters. It also shows that the 13 children who were finicky and became non-finicky were rated lower when finicky than when non-finicky in eleven traits (the difference in four of these being probably significant) and higher when finicky than when non-finicky in four traits (the difference in one of these being probably significant).

3. The writer believes that good handling of the eating situation has a good effect upon mealtime behavior indicative of the traits found to be more marked in finicky eaters. She also believes that some generalization of personality traits exists, and that the handling of the eating situation may affect generalized traits such as self-assertion and emotional control.

4. Finickiness in eating should not be considered as an isolated problem in child development, or as purely nutritional. It should be thought of as a problem often associated with other problems which are also significant in personality development.

APPENDIX

CASES I AND II

(Girl L and Boy J)

L—finicky eater who became non-finicky

J—exaggeratedly finicky eater who became non-finicky

L attended the nursery school of the Nursery Training School of Boston from July, 1926, to January, 1927, and from September, 1927, to September, 1928. J attended the nursery school of the Nursery Training School of Boston from July, 1927, to August, 1929. Both attended regularly except for L's going to Florida with her grandmother January to September, 1927, and for L's and J's absence because of whooping cough February to April, 1928.

Family:

American Negro

Father—successful lawyer

Mother—college graduate—at home

Maternal grandmother lives with family

Two children—L (girl) born July 22, 1924

J (boy) born August 26, 1925

Home environment:

House and furnishings—comfortable, attractive, and pleasant.

Mother—unusually intelligent, eager to learn, and cooperative, not very strong physically, severe illness for several months when children were in nursery school.

Father—intelligent and cooperative.

Grandmother—cooperative and helpful.

Health:

L—Mother says birth normal, general health always excellent, always a little under average weight for height, slight constipation at times,

Nursery-school doctor finds L has good posture, pot belly, large tonsils, and is slightly below average weight for height.

Whooping cough, February, 1928.

J—Mother says birth full-term, mother developed pyelitis.

General health always excellent. Very slightly under weight for height.

Nursery-school doctor finds J has fair posture, large tonsils, pot belly. Is slightly below average weight for height.

Whooping cough—February, 1928.

Tonsilectomy—April, 1928.

Intelligence:

I—IQ 115, PQ 139

J—IQ 112, PQ 126

EATING HABITS IN RELATION TO PERSONALITY DEVELOPMENT

Case I—L

Eating Habits and Treatment

Personality Development and Treatment

Mother's statement—September, 1927

L for first two weeks of life was wholly breast-fed, for three months she was half bottle-fed. At five months she began habit of stopping eating in the middle of feeding. At seven months she was given gruel and soup. She did not take them very willingly. Before she was a year old she was given vegetables. She has never been interested in food of any sort. There have been times when for a period she has refused a food which she has liked before and after. Mother has never given L dessert unless other dinner was finished.

L has always been quick to learn, imitative, and imaginative, curious about things; reasoning began to develop at two and a half years. Very strong willed. Has never had sharp fears, but used to be timid, now is cautious. Has shown fits of anger since one month old. Frequent tantrums till recently. Now harbors a grudge occasionally. She is affectionate, rarely cries or laughs, introspective, too self-assertive. Mother thinks L gets too much adult attention at home.

Statements from Nursery Training School record

September, 1926 (age 2 y. 1 m.). L does not eat well.

September, 1926. Active and skillful in use of body and hands, a bright child, eager and responsive. Has fits of anger when crossed, stubborn will, very self-assertive. "In-

December, 1926 (2 y. 4 m.). Eats regularly one or two helps of everything.

September, 1927 (3 y. 1 m.) (after long absence). L does not eat well, refusing one thing one day and eating it the next, very capricious "generally because she gains more attention by not eating."

December, 1927 (3 y. 4 m.). Eats regularly and with little difficulty.

May, 1928 (3 y. 9 m.). Eats well one or two helps each day. The treatment employed in the nursery school has been that of giving her no attention when she does not eat and removing food at the end of the meal without comment.

interested in adult attention to the exclusion of everything else. She should be ignored as much as possible."

December, 1926. L is unusually skillful in use of hands. Learns quickly. Improvement in control of anger. Emotionally unsteady. Still bids for adult attention but is much less self-assertive. Is becoming interested in other children.

September, 1927. Mentally keen and well developed. Interested in making things. Constant fits of anger. Emotionally unsteady. Self-expressive, and self-assertive. "An exaggerated desire for attention."

December, 1927. Gaining in emotional control. Less persistent in attracting attention. "L's mother and the teachers show no concern for L's attempt to gain attention. She receives an equal share of attention with J and other children. She has gained considerably in interests outside of herself."

May, 1928. L is generally emotionally steady. Self-expressive and self-reliant, sociable, sympathetic, helpful. "Greatly interested in everything about her. She is learning to overcome her desire for attention."

Statements from present study record

November, 1927 (3 y. 3 m.). L classified as a finicky eater.

November, 1927. Suppressed anger, in school seems more

During the month of October there was general improvement in eating because of mother's change of attitude about everything. This change is described as follows: "Mother's attitude changed during the month because of talk with Dr. Thom at Habit Clinic. Mother no longer gets so distressed over things which go wrong, takes more the attitude that it doesn't matter if L doesn't eat her dinner or do this thing or that, doesn't worry over her. Also in everything encourages L to express herself instead of only scolding her for wrong expression, sees far fewer things as 'wrong.' Mother had too high a standard of conduct for L and worried when she didn't live up to it. Also has given L more attention for her own sake, not for the sake of her wrong doings. Formerly stressed attitude of big sister, expected her to give things up to younger brother. This attitude has relaxed."

December, 1927 (3 y. 4 m.). There is great improvement in eating.

January, 1928 (3 y. 5 m.). L classified as non-finicky eater.

like moodiness. Improvement marked. Mother distressed about L's harboring a grudge. Much more self-expressive.

December, 1927. Anger improved, less moodiness. Self-assertion increased, seems to be playing for attention all the time.

January, 1928. Anger much improved. Less self-assertive but still playing for attention at times.

February, 1928. Still some-

what too great a display of anger, and still a bit too self-assertive.

April, 1928. Anger normal. Since six weeks' absence with whooping cough, is bidding for attention again.

EATING HABITS IN RELATION TO PERSONALITY DEVELOPMENT

Case II—J

Eating Habits and Treatment Personality Development and Treatment

Mother's statement—September, 1927

J was bottle-fed as a baby and took his food willingly until he was nine months old when he began the habit of occasionally not finishing the bottle. When solid food was presented he accepted it willingly, but never ate large quantities. He now refused onions, turnips, custard, and eggs. Mother has never given dessert unless other dinner has been finished.

J is bright, has vivid imagination. Asks questions, reasons. Has a strong will. Utterly fearless. Anger often flashes up and is quickly over. Affectionate, high-strung, impulsive, self-assertive, spontaneous, happy, friendly, loves music.

Statements from Nursery Training School record

August, 1927 (age 1 y. 11 m.). J eats fairly well until he is given food he doesn't like, then he stubbornly refuses to eat.

August, 1927. J is a bright child, learns quickly, keenly interested in everything at nursery school. Affectionate, self-reliant, happy, strong-willed, does not respect the rights of other children.

November, 1927 (2 y. 2 m.). He eats much better "since he receives no attention or seeming concern when he does not eat."

November, 1927. J is very responsive to nursery-school environment, perceptions are keen. Loses temper easily. "Too self-

February, 1928 (2 y. 5 m.).
J "generally eats well."

May, 1928 (2 y. 8 m.). He
eats regularly and well.

assertive." Plays for attention
of adults.

February, 1928. Skillful in
use of body and hands. Likes to
make things. Anger better con-
trolled. Emotionally steady.
Still too self-assertive, but now
he "shares willingly and re-
spects the rights of others."
Helpful, sympathetic.

May, 1928. "J is learning
to control his self-assertion. He
is becoming a leader."

Statements from present study record

November, 1927 (2 y. 2 m.).
J classified as exaggeratedly fin-
icky eater. "Fools, taken out of
room when fooling."

December, 1927 (2 y. 3 m.).
Classified as finicky eater.
"Great improvement, take din-
ner away occasionally."

January, 1928 (2 y. 4 m.).
There is record of improvement
but still some irregularity.

April, 1928 (2 y. 7 m.).
Classified as non-finicky eater,

November, 1927. Quick
temper. Teachers usually ig-
nore it, but sometimes isolate
J if temper is expressed anti-
socially. Problem in plus self-
assertion, slight improvement
recently. Teachers ignore it or
in most exaggerated expressions
of it isolate J.

December, 1927. Anger
slightly improved. Self-asser-
tion still a problem. Always
playing for attention.

January, 1928. Less display
of temper. Not playing for
attention so much.

April, 1928. Anger and self-
assertion are no longer prob-
lems.

CLASSIFICATION IN EATING HABITS AND AVERAGE RATINGS
IN PERSONALITY TRAITS

Cases I and II

L and J

	L—fin- icky Nov. '27 3 y. 3 m.	L—non- fin. Jan. '28 3 y. 5 m.	J—ex- fin. Nov. '27 2 y. 2 m.	J—fin- icky Dec. '27 2 y. 3 m.	J—non- fin. Apr. '28 2 y. 7 m.
I Body					
1. General habitual activity	2	3	4	4	3
2. General health	2	3	3	3	3
II. Intellectual habits					
1. <i>Quickness to learn</i>	3	3	4	4	4
2. Curiosity	4	4	4	4	3
3. Reasoning	4	3	4	4	3
4. Imagining	3	3	4	4	3
5. Perception	3	4	4	4	3
6. Manual skill	4	4	4	4	3
7. Speech	4	3	3	3	3
8. Constructive tendencies	4	3	4	4	3
III Emotional habits					
1. Fear	3	3	2	2	3
2. Anger	3	4	4	4	3
3. Affection	3	3	3	3	3
4. Excitability	3	3	3	3	4
5. Moodiness	4	3	2	3	3
IV Habitual attitudes and sentiments					
1. Self-assertion					
<i>a. Self-expression</i>	3	4	4	4	3
<i>b. Self-confidence</i>	3	3	4	4	4
<i>c. Desire for attention</i>	4	4	4	4	3
<i>d. Tenacity</i>	4	3	4	4	3
<i>e. Friendliness</i>	3	3	4	4	3
<i>f. Joy in use of power</i>	3	3	4	4	4
<i>g. Leadership</i>	3	3	4	4	3
2. Self-control					
<i>a. Regard for rights of others</i>	3	3	2	2	3
<i>b. Regard for authority</i>	3	3	2	2	3
<i>c. Control of power</i>					
bodily	3	3	4	4	3
emotional	2	3	3	2	3
intellectual	2	3	3	3	3
3. Happiness					
<i>a. Joy</i>	3	3	4	4	4
<i>b. Love of beauty</i>	4	4	4	4	3
<i>c. Wonder</i>	3	4	4	4	3
<i>d. Adjustment</i>	2	3	3	3	3

CASE III

(Girl 1)

Exaggeratedly finicky eater who became non-finicky

Attended nursery school of the Nursery Training School of Boston September, 1927, to September, 1928. Attended regularly except for measles January, 1928, and tonsilectomy March, 1928.

Family:

American white

Mother--dead

Father--roofer

Children--D (girl) born 1913

S (boy) born 1915

C (girl) born 1919

I (girl) born October 21, 1924

Paternal aunt--works

Home environment:

Father making a struggle to keep family together with aunt's help. Oldest sister, D, carries responsibility of house and children while father and aunt are at work. Father's shop in same building with home. Father, aunt, and oldest sister are intelligent and co-operative. Aunt and sister often attend mothers' meetings.

Health of I:

Father says birth normal. I has been generally well but has had worms a lot and much constipation. Always normal in weight. Active, sleeps well.

Nursery-school doctor finds posture poor, glands and tonsils somewhat enlarged. Slightly below average weight for height.

Measles--February, 1928.

Tonsilectomy--April, 1928.

Intelligence:

IQ 124 PQ 139

EATING HABITS IN RELATION TO PERSONALITY DEVELOPMENT

*Eating Habits and
Treatment**Personality Development and
Treatment**Father's statement--February, 1928*

I was breast-fed for fifteen months, took it willingly,

I is a bright child interested in making things since two and

Changed to bottle very unwillingly. Has always had a poor appetite, rarely hungry, perhaps once in two or three days. Eats very little. When I refuses to eat father does not substitute other foods, he just leaves it.

a half years old. Is destructive. Learns quickly. Talked at fifteen months. Always eager to investigate things. Imaginative. Gets angry with brother and sisters when they interfere with her. Not afraid of anything. Very affectionate, excited often, moody occasionally. Self-assertive, a little too "forward," self-confident, works hard to get her own way. Happy and adaptable. Father insists on obedience more than formerly.

Statements from Nursery Training School record

March, 1928 (age 3 y. 4 m.).
"I does not care much for food, and has to be urged to eat, especially desserts."

March, 1928. Fairly skillful in use of body. Very skillful in use of hands, constructive and original. Perceptions good, learns quickly, very curious, imaginative, reasoning good. Shows very little fear, or anger. Affectionate with greatly exaggerated demonstration. Self-assertion is too strong, frequently does unusual things in order to be noticed. Pays too little regard to authority. Prefers to play alone. "Needs to play more with the children and become objective in her interests."

June, 1928 (3 y. 7 m.). I eats well and regularly.

June, 1928. I is developing well in use of body and mind. Sometimes is angry when punished. Is less often than formerly too demonstrative in

her appeal for attention. Affection is more controlled. Loves her self more in play. Respects rights of others better. "Shows signs of leadership," is inclined to "boss," however.

Statements from present study record

November, 1927 (3 y. 0 m.). Classified as exaggeratedly finicky eater. Very irregular in eating. "Doesn't seem to be hungry."

December, 1927 (3 y. 1 m.). Classified as finicky eater. Very great improvement in regularity.

January, 1928 (3 y. 2 m.). Eating still irregular.

February, 1928 (3 y. 3 m.). Real improvement in eating.

March, 1928 (3 y. 4 m.). Classified as non-finicky eater, though has difficulty with desserts occasionally.

April, 1928 (3 y. 5 m.). Eating regularly though small amounts.

November, 1927. Problem in plus self-assertion. "At first seemed to want adult attention all the time." Has become more interested in play with other children.

December, 1927. Improvement in self-assertion. Still wants attention too much of the time.

January, 1928. Still wants attention, is defiant.

February, 1928. Some improvement in self-assertion.

March, 1928. Much better controlled.

April, 1928. No longer considered a problem in self-assertion.

CLASSIFICATION IN EATING HABITS AND AVERAGE RATINGS
IN PERSONALITY TRAITS

CASE III—I

	I—exaggera- tedly finicky Nov. 1927 (3 y. 0 m.)	I—finicky Dec. 1927 (3 y. 1 m.)	I—non- finicky Mar. 1928 (3 y. 4 m.)
I Body			
1. General habitual activity	3	3	3
2. General health	2	2	3
II Intellectual habits			
1. Quickness to learn	3	3	4
2. Curiosity	4	4	4
3. Reasoning	4	4	3
4. Imagining	4	4	4
5. Perception	4	4	3
6. Manual skill	3	4	4
7. Speech	4	4	4
8. Constructive tendencies	4	4	3
III Emotional habits			
1. Fear	3	3	3
2. Anger	2	2	2
3. Affection	4	4	5
4. Excitability	3	3	3
5. Moodiness	3	3	3
IV Habitual attitudes and sentiments			
1. Self-assertion			
a. Self-expression	4	4	4
b. Self-confidence	4	4	4
c. Desire for attention	4	4	4
d. Tenacity	3	3	4
e. Friendliness	4	4	4
f. Joy in use of power	4	4	4
g. Leadership	3	3	3
2. Self-control			
a. Regard for rights of others	3	3	3
b. Regard for authority	3	3	3
c. Control of power			
bodily	3	3	3
emotional	3	3	2
intellectual	3	3	3
3. Happiness			
a. Joy	3	3	3
b. Love of beauty	3	3	3
c. Wonder	3	3	3
d. Adjustment	3	3	3

CASE IV

(Boy T)

Exaggeratedly finicky eater who became non-finicky

Attended nursery school of the Nursery Training School of Boston from October, 1927, to December, 1929. Attended regularly.

Family:

American white.

Mother: At home. Sometimes takes in work to earn money.

Father: mechanic, earns about \$25 a week, periodic de-arter.

Children: I (girl) born August 1921

II (boy) born September 1922

J (girl) born November 1923

T (boy) born November 1924

L (boy) born July 1926

Home environment:

Father deserts periodically, an unpleasant, uncooperative person, is a tyrant when at home, mother afraid of him and has no influence with him. Mother says he is severe with the children. Mother is an unstable person---Psychopathic Hospital reports an IQ of 111 with marked emotional instability. Home is poorly kept. Mother talks big about her care of children, but does a very irregular and rather poor job with them. Is inclined to laugh at their misdemeanors. Attends mothers' meetings very regularly. All five of the children have been in the nursery school, and the influence of nursery-school teachers and workers in other agencies (Habit Clinic, Family Welfare Society, etc.) over a period of years has apparently made little impression on the home environment. All the children have been finicky eaters to a greater or less degree, the older boy, II, being one of the most exaggerated cases the nursery school has known. Mother caters to the children and gives them what they want.

Health of T:

Mother says birth normal, has been generally well except for chicken pox and whooping cough in 1925, mumps in 1927. Nursery-school doctor finds T has fair posture, flat foot, large tonsils, is slightly below average weight for height.

Intelligence:

IQ 102 PQ 120

EATING HABITS IN RELATION TO PERSONALITY DEVELOPMENT

<i>Eating Habits and Treatment</i>	<i>Personality Development and Treatment</i>
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Mother's statement—October, 1927

T was bottle-fed for eighteen or nineteen months. He has fixed dislikes for certain foods, but will eat plenty of the things he does like. Mother gives him what he wants. Father tries to make him eat what he doesn't like.

T is smart, an outgoing, friendly child, great talker, father's favorite, very lively and pleasant to have around. Wants his own way. Mother pays no attention to him when he misbehaves. Much easier to handle than her other children.

Statements from Nursery Training School record

December, 1927 (age 3 y. 1 m.). "T is a great eating problem and always would rather play than eat."

June, 1928 (3 y. 7 m.). "T takes pride in eating things he dislikes." Eats regularly though small amounts.

December, 1927. T is normally bright though sometimes slow to learn, skillful in use of body and hands, has keen perceptions and vivid imagination, reasoning is fair. T is timid, sometimes shows fear, has tantrums when not allowed his own way. He is very self-assertive, and self-reliant. He is a nervously high-strung child. He does not regard the rights of others. He is happy in the nursery school.

June, 1928. Unusually skillful in use of body. Very constructive in handwork, etc. No longer timid or fearful, tantrums better though sulks occasionally when he cannot have his way. Has developed well in relations with other children, is generally sympathetic and co-

November, 1928 (4 y. 0 m.).
Eats regularly and well—
average amount.

operative, is becoming a leader.
Still very high strung.

November, 1928. Has developed well in every respect. Rarely sulks or shows anger in nursery school. (Does with mother.) Attitude toward authority and other children is excellent.

Statements from present study record

November, 1927 (3 y. 0 m.).
T classified as exaggeratedly finicky eater. He dislikes many things. Eats one help when it is the thing he likes. Cod liver oil is withheld if he doesn't eat his dinner because he likes it better than vegetables, etc.

December, 1927 (3 y. 1 m.).
Eating much the same as last month.

January, 1928 (3 y. 2 m.).
Still not regular in eating.

February, 1928 (3 y. 3 m.).
Same.

March, 1928 (3 y. 4 m.).
Classified as finicky eater, though eating much better.

April, 1928 (3 y. 5 m.).
Classified as non-finicky eater.

November, 1927. Not normally interested in making things. Has improved slightly during month. Problem in minus self-assertion. Plays by himself most of the time. Doesn't talk. Face lights up only occasionally.

December, 1927. More constructive both in things and ideas. Tantrums have developed. Is normally self-assertive, defies authority occasionally.

January, 1928. No problem in constructiveness, anger, or self-assertion.

February, 1928. Same.

March, 1928. Same.

April, 1928. Same.

CLASSIFICATION OF EATING HABITS AND AVERAGE RATINGS
IN PERSONALITY TRAITS

Case IV—T

	T—exaggera- tedly finicky Nov. 1927 (3 y. 0. m.)	T—finicky Mar. 1928 (3 y. 4 m.)	T—non- finicky Apr. 1928 (3 y. 5 m.)
I Body			
1. General habitual activity	3	3	4
2. General health	3	3	4
II Intellectual habits			
1. Quickness to learn	3	4	3
2. Curiosity	3	4	4
3. Reasoning	3	3	4
4. Imagining	3	4	4
5. Perception	3	4	4
6. Manual skill	3	3	4
7. Speech	3	3	3
8. Constructive tendencies	2	4	4
III Emotional habits			
1. Fear	3	3	3
2. Anger	3	3	3
3. Affection	3	3	3
4. Excitability	4	4	4
5. Moodiness	3	3	3
IV Habitual attitudes and sentiments			
1. Self-assertion			
a. Self-expression	3	4	3
b. Self-confidence	3	4	3
c. Desire for attention	3	3	3
d. Tenacity	3	4	3
e. Friendliness	3	3	4
f. Joy in use of power	3	4	4
g. Leadership	3	3	4
2. Self-control			
a. Regard for rights of others	2	3	3
b. Regard for authority	3	3	3
c. Control of power			
bodily	3	3	3
emotional	3	3	3
intellectual	2	3	3
3. Happiness			
a. Joy	3	4	4
b. Love of beauty	4	4	4
c. Wonder	4	4	4
d. Adjustment	3	3	3

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LES HABITUDES DE MANGER DANS SES RAPPORTS AVEC LE DÉVELOPPEMENT DE LA PERSONNALITÉ DES ENFANTS AGÉS DE DEUX ET DE TROIS ANS

(Résumé)

Cet article est une étude des relations possibles entre le comportement d'un jeune enfant vis-à-vis de la nourriture qu'on lui donne à manger et de certains traits de personnalité. Les causes de l'habitude d'être très exigeant à l'égard de la nourriture, les méthodes employées pour la faire perdre, et son effet possible sur le développement total de l'enfant sont considérées des sujets importants par les pédiatres, les psychiatres, et les éducateurs.

En 1927-28 on a réuni des données sur de certains problèmes de comportement et de certains traits de personnalité de soixante-neuf (69) enfants âgés de deux et de trois ans dans deux écoles pour petits enfants. Chaque enfant a été classé (sur une échelle de cinq points) à l'égard de trente-et-un traits de personnalité et jugé en quatre problèmes de comportement par trois personnes une fois par mois pendant des périodes durant d'un à six mois. Il y a eu 90 notations (de 69 enfants) où l'on a classifié un enfant selon ses habitudes de manger. Cinquante-huit (58) en ont été non exigeants et trente-deux (32) exigeants. D'entre les 32 exigeants on a choisi dix extrêmement exigeants pour une étude spéciale. On a comparé les notations d'un groupe de treize des enfants qui ont été d'abord exigeants et sont devenus non exigeants. On a constaté le résultat moyen de chaque groupe pour chacun des 31 traits de personnalité et les proportions critiques des différences entre les groupes exigeant et non exigeant. Les données montrent que les mangeurs exigeants ont été plus enclins à la colère, à l'excitabilité, à la mauvaise humeur, à l'expression de soi-même, au désir d'attirer l'attention d'autrui, et à l'esprit directeur que les non exigeants. Ils ont été moins enclins à respecter les droits d'autrui et l'autorité, à gouverner leurs émotions et leur esprit, à la joie, et à l'ajustement que les non exigeant.

Une discussion d'un transfert possible de l'entraînement au domaine des traits de personnalité suit l'étude statistique. L'auteur croit qu'on peut trouver de l'évidence de quelque généralisation de ces traits dans les études de Harshorne et May sur la tromperie, le service et l'empire sur soi-même. Son expérience avec les jeunes enfants semble montrer qu'il peut exister un transfert d'une situation spécifique (telle qu'une situation où il s'agit d'un refus de nourriture pour attirer l'attention) à d'autres situations qui sont différentes mais à quelques égards semblables (telles que les situations générales où il s'agit des refus pour attirer l'attention) et de celles-ci à un trait plus généralisé (tel que l'assertion de soi-même). Dans l'appendice on donne l'histoire de quelques cas pour servir d'exemples du développement des habitudes de manger, plus ou moins parallèle au développement de l'assertion de soi-même, du gouvernement des émotions ou d'autres traits.

On conclut que la direction des habitudes de manger d'un jeune enfant est probablement non seulement un problème important de nutrition mais aussi un problème important de personnalité.

ELMER

ESSGEWOHNHEITEN IN IHRER BEZIEHUNG ZUR ENTWICKLUNG DER PERSÖNLICHKEIT BEI ZWEI- UND DREIJÄHRIGEN KINDERN

(Referat)

Diese Arbeit ist eine Untersuchung der gegenseitigen Beziehungen zwischen dem Benehmen eines jungen Kindes der ihm dargebotenen Nahrung gegenüber und gewissen Persönlichkeitseigenschaften. Die Gründe des wählerischen Essens [finicky eating], dessen Besserung, und dessen mögliche Einwirkung auf die Gesamtentwicklung des Kindes werden von Kinderärzten, Psychiatern, und Erziehern als wichtige Sachen betrachtet.

In 1927-1928 wurden Daten gesammelt in Bezug auf gewisse Benehmensaufgaben [problems of conduct] und gewisse Persönlichkeitseigenschaften von 69 zwei- und dreijährigen Kindern in zwei Pflegeschulen. Jedes Kind wurde von 3 Personen in Bezug auf 31 Persönlichkeitseigenschaften an einem fünfpunktigen Massstab abgeschätzt [rated on a five-point scale] und in Bezug auf 4 Benehmensaufgaben beurteilt. Diese Abschätzungen und Urteile fanden jeden Monat während ein bis sieben Monaten statt. Es gab 90 Notierungen (an 69 Kindern) in denen ein Kind in Bezug auf dessen Essgewohnheiten klassifiziert wurde. Von diesen bezogen sich 58 auf nicht-wählerische und 32 auf wählerische Esser. Eine Gruppe bestehend aus 10 besonders wählerischen Kindern wurde unter den 32 wählerischen Essern zur besonderen Untersuchung ausgelesen. Die Notierungen über eine Gruppe bestehend aus 13 der Kinder die zuerst wählerisch waren und dann nicht-wählerisch wurden, wurden verglichen. Man ermittelte den mittleren Abschätzungswert [average rating] für jede Gruppe in Bezug auf jede der 31 Persönlichkeitseigenschaften und das kritische Verhältnis der Unterschiede [critical ratio of the differences] zwischen der wählerischen und der nicht-wählerischen Gruppe. Die Befunde erweisen, dass die wählerischen Esser stärker zu Zorn, Aufregbarkeit, Launenhaftigkeit, Selbstäusserung, [self-expression] Verlangen danach, bemerkt zu werden [desire for attention], und Fähigkeit zur Führerschaft [leadership] neigten, als die nicht-wählerischen. Sie neigten weniger zur Berücksichtigung der Rechte anderer, zum Respekt der Autorität gegenüber, zur affektiven und intellektuellen Selbstbeherrschung, zur Freude, und zur (sozialen) Anpassung als die nicht-wählerischen Kinder.

Der statistischen Untersuchung folgt eine Besprechung der möglichen Übertragung der Einübung im Bereich der Persönlichkeitseigenschaften. Die Verfasserin ist der Meinung, dass in den Untersuchungen von Hartshorne und May über Betrug, Behülflichkeit und Selbstbeherrschung [*Studies of Deceit, Service, and Self-control*] Beweis dafür zu finden ist, dass diese Eigenschaften bis zu einem gewissen Grade verallgemeinert werden. Ihre Erfahrungen mit jungen Kindern weisen darauf hin, dass mehr-weniger eine Übertragung stattfinden kann von einer spezifischen Situation (wie zum Beispiel eine Situation der Nahrungsverweigerung-Verlangen nach Bemerkung) auf andere, aber in mehreren Beziehungen ähnliche, Situationen (wie, zum Beispiel, Verweigerung-Aufmerksamkeitsverlangen-Situationen im Allgemeinen [refusal-attention-getting situations in general] und von letzteren wieder auf eine mehr verallgemeinerte Eigenschaft (wie, zum Beispiel, die Selbstäusserung). Die Entwicklung der Essgewohnheiten, die mehr-weniger mit der Entwicklung in Bezug auf Selbstäusserung, affektive Selbstbeherrschung und andere Eigenschaften parallel läuft, wird im Anhang durch die Geschichten typischer Fälle erläutert.

Man zieht den Schluss, dass die Lenkung der Essgewohnheiten des jungen Kindes wahrscheinlich nicht nur ein wichtiges Nahrungsproblem, sondern auch ein wichtiges Persönlichkeitsproblem darstellt.

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GENETIC PSYCHOLOGY MONOGRAPHS

Child Behavior, Animal Behavior,
and Comparative Psychology

COORDINATING MECHANISMS OF THE SPINAL CORD*¹

From the Psychological Laboratories of the University of Chicago

By

OTIS CLARENCE INGEBRITSEN

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Worcester, Massachusetts

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I

INTRODUCTION

It is the rule rather than the exception for discussions and descriptions of tracts of the spinal cord to treat of them as if they had exclusive function and very specific limitations. Previous experimental evidence has indicated less specificity of function in the tracts of the cord than might have been expected from its known anatomical structure. From an examination of the literature it is apparent that there is a great deal of contradictory evidence regarding the fineness of localization in or the accuracy of the restriction of function to the anatomical paths of the cord. Destruction or impairment of tracts in the cord, supposedly having exclusive sensory or motor functions, is frequently not followed by permanent incapacity. Instances of this can be found in clinical material where the spinal cord has been impaired through injury or disease, as well as in animals subjected to experimental lesions of the cord. Physiologists and psychologists interested in behavior studies on animals have gathered a mass of evidence which seems to point to much less specificity of function of the tracts of the cord than that ordinarily indicated.

Brown-Séquard (2, 3) held that the paths subserving cutaneous sensation ascend the spinal cord *entirely contralateral to the initiating sense-organs*, the decussation of the afferent channels occurring soon after their entrance into the cord. He claimed to have

established this fact in guinea pigs, dogs, cats, rabbits, and sheep, by hemisection of the spinal cord. He maintained that injuries confined largely to one side of the cord produced motor paralysis on the side of the lesion and sensory paralysis or impairment on the side opposite the lesion.

Many experimenters working on animals have contributed a mass of conflicting evidence, some of which tends to support the Brown-Séquard hypothesis, and some of which is directly opposed to it. Their results furnish considerable evidence as to restitution of sensory and motor functions of the cord with some suggestions as to how this restitution takes place.

Sherrington (19) says that it was known at the time of Hippocrates and the time of Galen that an effect of lateral hemisection of the cord is to impair the motor and sensory functions of the parts of the body innervated by the spinal nerves behind and on the same side as the section. According to Sherrington's account, it was Cooper working on the dog in 1803 who first reported recovery of motor functions.

A number of investigators have made observations on recovery or partial restitution of sensory functions. Weiss (22) reported that after hemisection in the hindmost thoracic region in the dog there was sensory defect in the opposite limb for all kinds of cutaneous sensation and for muscular sensation. This depression was said to be permanent for the opposite limb, and some sensory deficiency was apparent in the hind limb on the same side. He found that a second section on the other side and one segment farther headward abol-

ished permanently all sensation posterior to the lesion. Osawa (12) and Borgherini (1) [cited by Sherrington (19)] performed two successive hemisections on the dog in the thoracic region at intervals of seven segments. Restoration of sensitivity was reported to be long delayed and imperfect. Ferrier (4), after observation of a monkey for a period of 18 days after hemisection in the dorsal region, described the effect as absolute paralysis (motor) on the side of the lesion and absolute loss of sensation on the side opposite the lesion. Turner's (20) experiments with hemisection of the cord in monkeys gave evidence that the normal course of sensations was up the opposite side of the cord. His findings agreed with the Brown-Séquard hypothesis, but he did find that restitution of sensation took place on the side opposite the lesion. In one case he reported that from the 53rd day on it was impossible to say which had been the anaesthetic limb. He performed a second operation, a hemisection on the opposite side and three segments farther forward in the dorsal region on the 68th day after the original operation and found no return of sensation or movement on the other side up to the 113th day after the original operation. Mott (10), working with monkeys, claimed that with the return of movement the apparent loss of sensibility disappears. Schafer (17) reported sensation not lost on the side of the lesion but dulled temporarily. After a few days, sensation returned on the side of the lesion, while at no time was there any loss of sensation on the side opposite the lesion. He performed experiments on the cat and the monkey.

Most workers seem to be in agreement that restitution of motor function does occur in the limb or limbs on the side of the hemisection. Weiss (22) found restoration of motor function for standing, walking, and running, in the course of some weeks. Movements of the affected limb became almost perfect and were well associated with movements of the other limbs. Mott (10) and Turner (20) are agreed that, after two months, return of movements is almost complete in monkeys with hemisection of the cord. Mott indicated that bilaterally associated movements were first to return and that only some time later would the animal be able to perform unilateral movements on the side of the lesion. He found that the higher the lesion was above the limb the quicker the return of motor function. Schafer (17) maintained that all movements except purely voluntary ones are restored in the limb on the side of the lesion but he did not define voluntary movements. Turner found no return of motor function in the hind limbs of the monkey after double hemisection of the cord in which the lesions were separated by three segments, but Osawa (12) and Borgherini (1) found restoration of motility in the hind legs of the dog after similar lesions with a separation of six or seven segments.

Restoration or restitution of function seems to be rather common after other types of section in the spinal cord. Sherrington (18) reported almost complete division of the posterior columns of the cord in the lower thoracic region of the monkey which was followed, after ten days, by no definite abnormality of

movement or sensation. Schafer (17), working with the cat and the monkey, made section of the dorsal cerebellar tract on one or both sides, section of the ventral cerebellar tract on one or both sides, and section of both dorsal and ventral cerebellar tracts on one side. Lesions of these tracts either together or singly produced no obvious symptoms. Sensation and motion seemed unimpaired and the pupil was unaffected. No obvious symptoms were noticeable even when some of the pyramidal fibers were included. Rothmann (16) was able to demonstrate the formation of motor habits in the monkey in the absence of any possible influence from the pyramidal tracts even when the rubro-spinal tract on the side of the hand to be used had been divided. Lashley and Ball (7) gave clear evidence that the maze performance of the rat does not depend on the integrity of any specific tracts in the spinal cord of the rat.

The evidence seems to indicate a more or less complete recovery or restitution of motor functions in animals subjected to lesion of the spinal cord. In the cases where animals have been observed over some time following the operation this seems to be undisputed except in the case of Ferrier's observations on hemisections in monkeys and Turner's work on double hemisection in the monkey. All workers here cited, with the exception of Weiss and Ferrier, are agreed that there is return of sensory function on the side opposite the lesion. Here again it seems to be a matter of time after the operation before the sensory functions of the cord are partly or fully restored. In the cases

where two lesions have been made there seems to be a relation between the number of intact segments separating the sections and the return of function in the members affected.

II

PURPOSE OF THE STUDY

It was the plan of this study to obtain some evidence relative to the problems of spinal conduction and recovery from effects of lesions in the spinal cord. With respect to normal conduction it was hoped that some evidence might be obtained on the rôle of long tracts and of arcuate fibers in sensory and motor organization, on the degree of specificity of tracts, and as to how much of coordinated behavior is spinal and how much is controlled by higher centers.

With reference to the character of recovery, questions have been raised as to whether recoverable symptoms are evidence of diaschisis or of destruction of normally functional paths. There are also the questions, whether the recovery is spontaneous or the result of a process of re-education, and, if the latter, in what manner re-education occurs. Is it a matter of vicarious acquisition of functions by tracts not normally involved or by more efficient utilization of residual functions?

Evidence was sought as to the limits of recovery. Here we have the questions of rate of recovery with and without exercise, the limits of accuracy of control, and the limits of complexity of coordination that are possible.

Lastly, it was hoped that some information might be obtained as to the mechanisms of recovery. Here we have to deal with the questions of capacity of re-

covery in isolated segments of the cord, distance of separation in cases of double block, and various dynamic factors that may be influential in recovery.

III

ANATOMY OF THE RAT'S CORD

The conduction paths of the spinal cord of the rat have not been completely described, but Lashley and Ball (7) have summarized the previous descriptions of tracts in the rat cord and have been able to add further details from their work. Their cases involved the interruption of all the tracts in the cervical cord in one or another animal and these tracts were traced in so far as they were revealed by the Marchi technique. Figure 1, which is a composite from figures in Plates 1

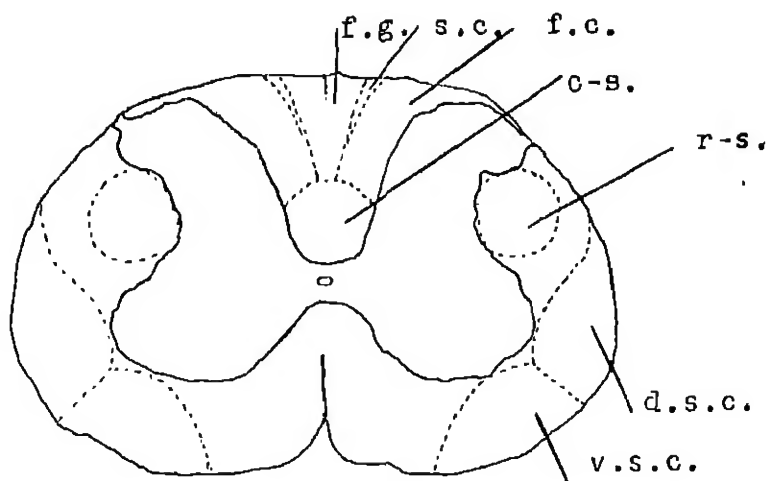


FIGURE 1

CROSS-SECTION OF THE CERVICAL CORD OF THE RAT, SHOWING
LOCATION OF THE PRINCIPAL TRACTS

f.g.—fasciculus gracilis
s.c.—Schultz's comma
f.c.—fasciculus cuneatus
c-s.—cerebro-spinal

r-s.—rubro-spinal
d.s.c.—dorsal spino-cerebellar
v.s.c.—ventral spino-cerebellar

and 2 of the Lashley and Ball study, shows the positions of tracts in the cervical cord of the rat so far as evidence at hand permits of their exact location.

Descending tracts figured are the cortico-spinal, the rubro-spinal, and Schultz's comma tract. The cortico-spinal tract occupies a median ventral position in the dorsal funiculus. The rubro-spinal tract is shown to be ventro-lateral to the dorsal horns. Schultz's comma tract is found between the fasciculus gracilis and the fasciculus cuneatus on each side.

Ascending tracts include the fasciculi gracilis and cuneatus of the dorsal funiculus, the fasciculus spino-cerebellaris dorsalis in the more dorsal part of the lateral funiculus, and the fasciculus spino-cerebellaris ventralis toward the ventral side of the lateral funiculus. No other ascending tracts are evident in enough detail in Marchi preparations to permit of description. It is probable that there are no long ascending or descending paths in the ventral funiculus of the rat.

Descending tracts other than those noted for the rat have been rather definitely located in the human cord. Villiger (21) describes tecto-spinal and vestibulo-spinal tracts, some of the fibers of which descend in the ventral funiculus and others in the lateral funiculus. He also describes a thalamo-spinal bundle in the lateral funiculus just medial to the ventral spino-cerebellar tract. Such tracts probably exist in the rat cord but staining methods have not been successful in their delineation.

Villiger describes no long ascending tracts in the

ventral funiculus of man. He indicates that there are in the lateral column spino-olivary, spino-thalamic, and spino-tectal connections. Lashley suggests, without conclusive evidence, the origin in the rat of spino-tectal fibers in the ventral funiculus. It seems probable that in the rat cord there are ascending fibers similar to those in man, but degeneration studies have not succeeded in demonstrating their exact location.

The arrangement of tracts in the cord of the rat is, with the exception of the cortico-spinal tract, similar to that obtaining in man, so far as is known. The evidence for variation in position of the cortico-spinal tract in different species has been summarized by Linowiecki (8). The work of Ranson (14, 15) and others has established the fact of complete decussation of the cortico-spinal fibers to occupy a median ventral position in the dorsal funiculus of the cord. There are no lateral or ventral pyramidal fibers in the rat cord. The rubro-spinal fibers probably cross in the midbrain as they do in man. The spino-thalamic tract is a crossed tract in the cord; others, so far as is known, ascend on the same side of the cord.

IV

TECHNIQUES

OPERATION

Operations were performed on adult rats in the cervical region, involving, in one animal or another, hemisection, double hemisection or section of the dorsal portion of the cord. In one case a complete transection of the cord was made at the level of the seventh thoracic root. Under ether anaesthesia and with aseptic precautions a slit about 15 millimeters long was made in the skin of the back of the neck and the muscle divided in the midline so as to expose the second cervical neural arch. After removal of this arch with bone forceps, an incision was made in the dura and then, by means of an iridectomy knife, one-half of the cord was severed from the midline to either right or left side. After injury to the cord the muscles and skin were united above the cord by interrupted sutures and the wound was dressed with cotton and pariodian. The cases put through two operations were subjected to similar procedure in the second one, except that the cord was exposed and sectioned farther caudad. The time that elapsed between first and second operations in the seven cases of double section reported in the results varied from 19 to 37 days.

Great difficulty was experienced in getting animals to survive a second operation and in many of the cases they did not survive the first operation. An attempt was made to have the two lesions as far forward in the

cord as possible in order to be in front of the innervation of the front limb on either side. Goering (5) has shown that the nerve supply of the brachial plexus of the rat begins with the fifth cervical root, and so it was usually attempted to make the more caudad lesion at that level or forward of it.

Porter's (13) work showed that in the dog and the rabbit the respiratory impulses pass down the lateral funiculi of the cord to reach the phrenic nuclei at the fourth cervical level. This suggests that the high mortality among cases subjected to double lesion may have been due to interference with or blockage of respiratory impulses. The work of Lashley and Ball (7) does not support this conclusion, since they succeeded in making complete section of both lateral columns at the second cervical level.

HISTOLOGICAL TECHNIQUE

The Marchi staining technique to show degeneration could not be used because of the long time interval between operation and necropsy, consequently a general fiber stain was used. Horizontal serial sections of each cord specimen were prepared and stained by Morgan's (9) iron-hematoxylin method for fiber.

RECONSTRUCTION

This included measurement of each section with identification of major tracts and plotting of the lesion on cross-sectional diagrams made from camera-lucida drawings of cross-sections in the cervical cord.

TESTS AND METHODS OF STUDYING BEHAVIOR

1. *Tests of sensitivity* were used at various times after operation. They included such things as pinching, pricking, and faradic stimulation of the skin, pulling hairs, attaching a clip to the skin of the flank or foot. It was difficult to make any adequate test of tactile sensitivity, but evidences of it were obtained at times when, after a series of faradic stimuli, the animal would squeal to touch alone or to stroking of the hair.

2. Observations were made on *motor control* in standing, walking, running, climbing, digging, etc.

3. *Head-limb coordinations* were noted where such evidence could be obtained and they were tested by using adhesive tape over the vibrissae on one or both sides to stimulate use of fore or hind limbs.

4. *Motor learning* was tested by the use of an elevated runway $1\frac{1}{2}$ inches wide and about 1 meter long, by the use of a simple T-maze (Figure 2), by the latch-box (Figure 3), and the digging-box.

The elevated runway gave an opportunity to observe the ability of the animal to orient itself and to main-

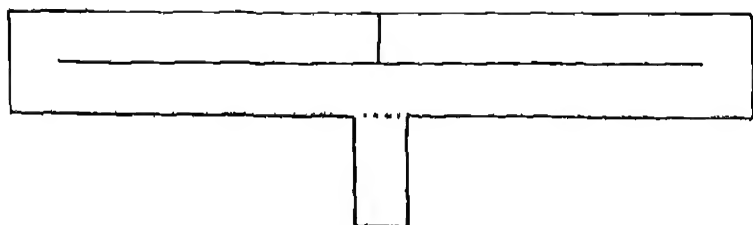


FIGURE 2
SIMPLE T-MAZE

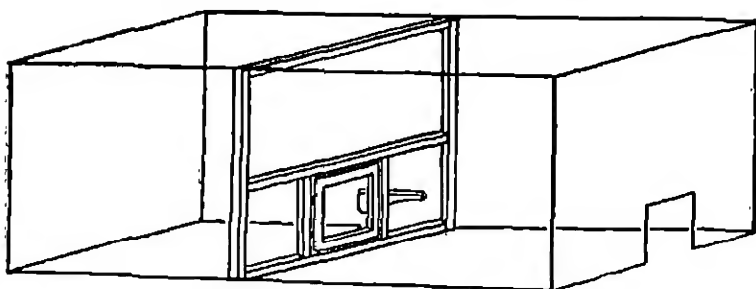


FIGURE 3
LATCH-BOX

tain its balance under conditions where the normal animal very readily does both. The simple maze afforded evidence of the ability of the animal to form motor habits requiring integration of a series of acts. The latch-box was used to obtain evidence of ability to manipulate devices with the hand and served therefore as a test of finer movements. A removable partition between starting compartment and food compartment in the latch-box allowed the substitution of latch-mechanisms in different positions when the animal had learned one. They were first tried on a problem requiring manipulation of a lever placed at the left side of the door and at a distance of about 3 inches from the floor. Next, a similar lever was used on the opposite side of the door. Finally, to test the animal's ability to get up on its hind legs and reach up for manipulation, the lever was placed about 8 inches above the floor.

On the latch-box the animals were given about five minutes to explore and to feed in the apparatus for

three days preceding the regular runs. They were given five trials per day until their time records showed no further improvement. With the maze they were given three days feeding in the food-box and then five trials daily until they reached a criterion of ten errorless runs on two days.

CORTICAL STIMULATION

The motor cortex was explored in most of the cases by means of bipolar stimulation. This was done to obtain evidence of limb movements; however, since limb movements are sometimes difficult or impossible to elicit in the normal animal, the results may not be very significant.

CONTROLS

A group of normal animals was used on the various pieces of apparatus for purposes of control.

V

PROTOCOLS

CASES OF DOUBLE SECTION IN THE CERVICAL REGION

Animals used for operation were all mature, one hundred days of age or more at the time of the first operation.

No. 1. Female Albino

Lesions. Figure 4A shows the maximum extent of the lesion on the right at the level of the second cervical root. This lesion interrupted all of the right side of the cord with the exception of part of the dorsal and ventral funiculi. Only a small part at the right side of the cortico-spinal tract has been injured. Tracts completely interrupted are the fasciculus cuneatus, the dorsal and ventral cerebellar tracts, and the rubro-spinal tract. The second lesion (Figure 4B), at the level of the fourth cervical root on the left side, has crossed the midline, and, slanting toward the left, has interrupted all of the left half of the cord with the exception of a small part of the lateral funiculus. At this level the tracts of the dorsal funiculus have been completely severed on both sides with the exception of a small portion of the right fasciculus cuneatus. All known long tracts on the left side of the cord have been severed except the ventral spino-cerebellar tract.

Sensitivity. Tests after the second operation gave no evidence of pain sensitivity up to the ninth day after the second operation. More than 30 days

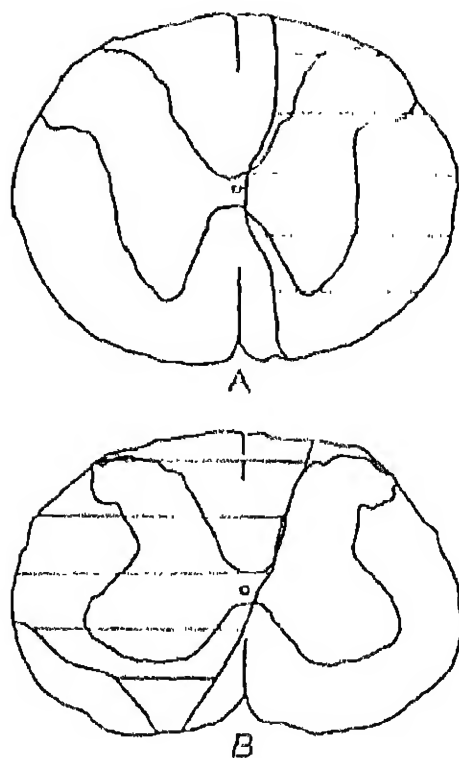


FIGURE 4

after the second operation the animal amputated a forefoot and seemed to suffer no pain from the wound. She had to be killed because of infection in the wound a few days later so that tests were not completed in her case.

Motor coordination. She was quite capable of standing, walking, running, and climbing within 20 days after the second operation. She was tried but once on the elevated path and she could not cling to it

at that time. This was on the eighth day after the second operation.

Head-limb coordinations. Two days after the second operation, when the left forepaw was brought up to the ear in what appeared to be a face-washing movement, the left hind foot moved synchronously with it. On the eighth day after the second operation she was able to use the left hand in face washing but the right was ineffective in this act.

Motor learning. She was tried only on the latch-box. On the fourth day her average time for the performance was 3 seconds which approximates the speed of the normal animal. She showed a ready transfer to the latch on the opposite side of the door.

For this animal, with no long tract intact except the ventral spino-cerebellar tract on the left side, the only impairment which remained very prominent was the evident analgesia and motor impairment of the right forepaw.

No. 2. Female Albino

Lesions. The lesion on the left at the second cervical level included the whole dorsal funiculus on both sides of the midline and interrupted all of the left side of the cord with the exception of the ventral funiculus (Figure 5A). All ascending tracts of the dorsal funiculus have been cut at this level as well as the whole descending cortico-spinal tract. The rubro-spinal tract, the dorsal and ventral spino-cerebellar tracts on the left have all been completely interrupted.

The lesion on the right at the fifth cervical root inter-

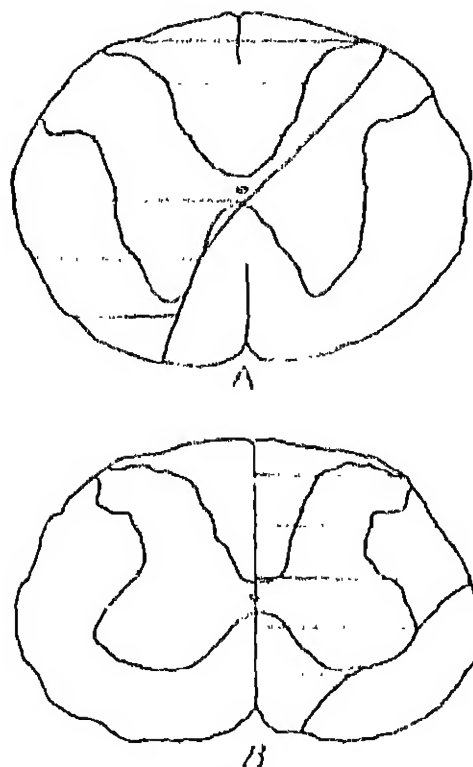


FIGURE 5

rupted all of the right side of the cord with the exception of the ventro-lateral portion of the lateral funiculus. Thus, on this side of the cord, all long tracts were cut except the ventral spino-cerebellar tract and a part of the dorsal cerebellar tract (Figure 5B).

Sensitivity. Cutaneous and pain sensitivity were apparent after the second operation. There were apparent defects in proprioceptive sensitivity, evidenced

by the animal's walk on the elevated pathway and by the fact that she frequently stepped on the dorsum of the right foot in walking on a smooth surface.

Motor control. Locomotion on flat surfaces became almost perfect after some time, although there was always much difficulty apparent in the walk on the elevated pathway. She was able to bring the left hand up to the latch in manipulating the latch-box, but very seldom made use of the hand in opening the mechanism. She used the forepaws in digging, never accompanying this by movements of the hind legs to scratch away accumulated shavings.

Head-limb coordinations. When the vibrissae were taped, she was able to remove the tape from the right side by the use of the right forepaw; only ineffectual movements with the left forepaw occurred in such instances. I once noted scratching of the nose and ear on the left side by the left hind foot. The right hind foot was freely used for scratching.

Learning. On the elevated pathway this animal was tried for one week, several trials a day, before she succeeded in walking the entire length of the path, a distance of one meter, without falling to the net below. Her progress was always slow and much difficulty was evident in balancing, for her chin was pressed down hard on the walk and the right forepaw was thrust over the right side of the pole with the fingers widely fanned out. She reached the criterion on the maze but trial and error records were considerably poorer than those of any normal animal. She learned the latch-box manipulation in any of the positions used in this prob-

lem, and reduced her time of performance to approximately that of a normal animal.

Cortical stimulation. No limb movements were obtained to stimulation of the left motor cortex. A very slight adduction of the left forepaw was obtained to strong stimulation of the right motor cortex.

In this case, with all known long tracts severed except the spino-cerebellar tracts on the right side of the cord, there was little evidence of impairment except for some of the finer movements of the left forepaw. There was clear evidence of conduction past the block in the cord. Complexity of integration seemed to approach that of the normal animal since she was able to learn although she took longer to reach the criteria of learning than did normal animals.

No. 3. Female Albino

Lesions. On the right side at the second cervical level the whole right half of the cord was severed with the exception of the most ventro-lateral portion of the right lateral funiculus (Figure 6A). The lesion on the left (Figure 6B) side at the level of the fourth cervical root included the right fasciculus gracilis and cut all the left side of the cord except the ventral funiculus. Long tracts completely severed in this cord were the fasciculi gracilis and cuneatus, the cortico-spinal, the dorsal cerebellar on the right, and both rubro-spinal tracts. Tracts remaining were the left ventral spino-cerebellar tract and parts of the left dorsal spino-cerebellar tract, together with a portion only of the right ventral spino-cerebellar tract.

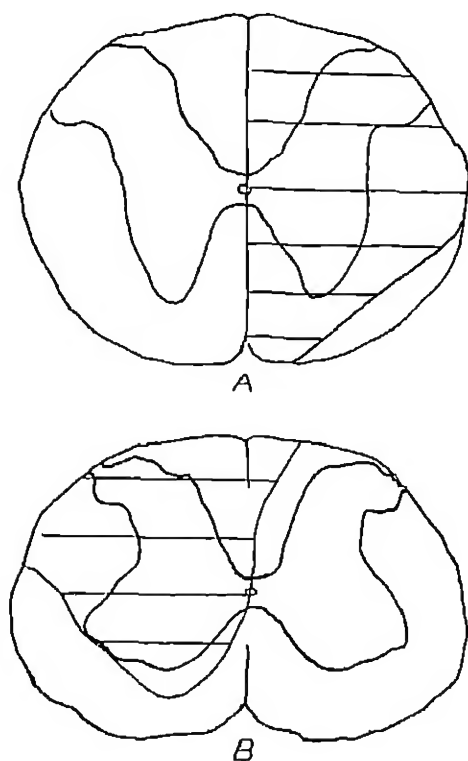


FIGURE 6

Sensitivity. Tests at various times did not show any marked degree of impairment in pain sensitivity. She responded to pinching, pricking the skin, electrical stimulation, and pulling hairs, much the same as does a normal animal. She squealed to all these stimuli and reacted to the position of the stimulus. There was doubtful evidence of tactile sensitivity since there was not much squealing to contact on any part of the body

after electrical stimulation. The most evident permanent impairment was in proprioceptive sensitivity.

Motor control. After the first operation the animal moved for some days chiefly by twisting to the left side. She fell to the left side frequently and had difficulty in righting herself. There was a slow improvement in locomotion up to the time of the second operation. Two days after the second operation she again showed the twist to the left side in locomotion, and the right limbs were less perfectly controlled than the left. She sidled to the left with the body highly arched, frequently falling to the left side. Her progress along the elevated pathway was slow and, as she went, the right forepaw was over the edge, making contact with the side of the pole at each step that she took. Difficulties that did not appear in her walk on a flat surface showed very plainly on the elevated pathway. The limbs were moved in the same order as those of the normal animal but the control of the limbs was far from normal at any time. Her head was kept down close to the right side of the pole as she walked on it. In the latch-box she used the left hand exclusively, no matter in what position the lever was placed. The left forepaw was much more effectively used in digging than was the right. Both hands were used, but the right moved stiffly, while she often used her mouth to help remove shavings from the doorway.

Head-limb coordinations. Face cleaning with the left hand occurred four days after the second operation. She was able to remove adhesive tape from the left vibrissae by the use of the left forepaw; the right

made only ineffectual movements when the right vibrissae were taped. In the latter case the right hand was thrust forward but did not reach the face. Although there was scratching of the neck region by the left hind foot, I never observed scratching in the head region by the right hind foot.

Motor learning. It took her some days to learn to walk the elevated pathway. The greatest difficulty was in control of the hind legs, which were allowed to hang over the edges of the walk when the animal was placed on the runway, and frequently slipped over the sides as she attempted to move forward. Although in her first attempts she often fell to the net below, she finally mastered the task and walked the whole distance without falling. On the latch-box she was slow to react, never reducing her average time to equal that of a normal animal. She reached the criterion of learning in the maze, with trial and error records much poorer than those of the poorest normal record.

Cortical stimulation. The only movement in response to stimulation of the motor cortex was adduction of the left forepaw.

This case, with all long tracts interrupted except the ventral spino-cerebellar on the left side, showed little sensory impairment except for proprioception. Stimuli in the head region passed the block in the cord and aroused movements of all limbs except the right hind limb. I had no evidence of the use of the latter member in response to head stimulations. She was generally slower than a normal animal but she succeeded in learning all the problems presented to her.

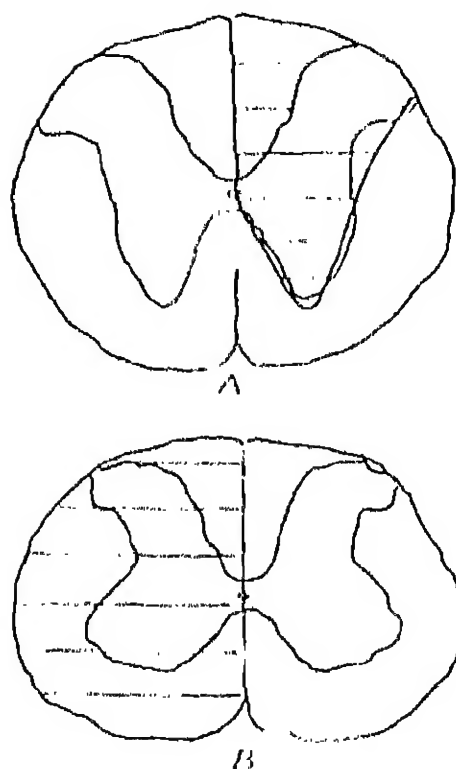


FIGURE 7

No. 4. Hooded Male

Lesions. The lesion at the right at the first cervical level was not a complete hemisection. It interrupted only the dorsal funiculus on the right side and all of the gray matter (Figure 7A). The lesion on the left side four segments farther caudad (Figure 7B) was a complete hemisection. In this animal the only long tracts left intact were those of the right lateral

funiculus: the right rubro-spinal, the dorsal and ventral spino-cerebellar tracts.

Sensitivity. When tested at different times by means of pulling hairs, pinching the skin with forceps or clips, or with electrical stimulation of the skin, he seemed equally sensitive on either side of the body. In some instances it did seem that he was more sensitive on the left side than on the right side, judging by the strength of stimuli that was required to elicit squealing, but this behavior was too variable to warrant any definite conclusion. Cleaning activity on both sides of the body was frequently noted in this animal even though there was a complete interruption of the left side of the cord.

Motor control. After the first operation there was much turning to the left side up to the end of the second week when the walk had very much improved, although it was slow and the back was highly arched. After the second operation there was little locomotion for some days and the animal crawled about chiefly by the use of the right forepaw. The full use of the left forepaw in walking never was recovered although the animal was kept under observation for a year after the second operation. In the latch-box he adhered strictly to the use of the right hand, no matter in what position the lever was placed. When feeding on pellets, he always grasped them with the right hand, using the left fist to brace against the food. In the digging tests he used both hands, although the left one was not very effective in the act. He, too, used the mouth to assist in removing shavings from the doorway.

Head-limb coordinations. Effective face washing was done with the right forepaw and it was used for the removal of adhesive tape from the right vibrissae. The left forepaw was brought up in the face-washing gesture, but it never made contact with any parts above the mouth, so that he was not successful in removing adhesive tape from the left vibrissae with this hand. The hind leg on the right was quite freely used for scratching-reactions to the head region; the hind leg on the left was rarely used for such reactions although I noted on several occasions scratching of the left ear by the left hind foot. This movement was noted once when adhesive tape had been placed over the left vibrissae.

Motor learning. He could not walk the elevated pathway when first tried on it, six months after the second operation. It was only after many falls from it that he learned to keep all feet placed on top, and then the left forepaw was always closed in a fist as he progressed. He reached the criterion on the maze but his trial and error records were poorer than those of any normal animal. With practice on the latch-box he learned to operate the mechanism in about the same time as a normal animal and had no trouble in transferring from one lever position to another.

Cortical stimulation. Stimulation of the frontal areas of the cortex produced movements of the forelegs only. The left foreleg showed adduction in response to stimulation of the right cortex and the right foreleg adduction to stimulation of the left cortex.

This animal, with complete block of the cord on the

left side, and only lateral and ventral tracts on the right side intact, showed no particular sensory impairment, and motor impairment of the left forepaw for finer movements only. There was clear evidence of conduction from the head region past the block in the cord. He was able to adapt to the elevated pathway and to the digging-box, and demonstrated no marked disability in acquisition of latch-box and maze integrations.

No. 5. Female Albino

Lesions. The lesions in this case were practically the same as for those of the animal just reported, except that they were reversed in position and two segments closer together. The lesion on the left, at the second cervical level, extended down the midline beyond the level of the ventral median fissure, including a part of the left median ventral funiculus. It severed the left gracilis and cuneatus and the left half of the cortico-spinal tract and took in all of the gray matter on the left side (Figure 8A). The lesion at the right was a practically complete hemisection at the level of the fourth cervical root (Figure B). The only intact long tracts in this cord were those of the left lateral funiculus, namely, the rubro-spinal and the dorsal and ventral spino-cerebellar tracts.

Sensitivity. There was no evident difference in this respect between this animal and No. 4 previously reported.

Motor control. After the first operation the left forepaw seemed to be much more seriously affected than the left hind leg. She frequently stepped on the

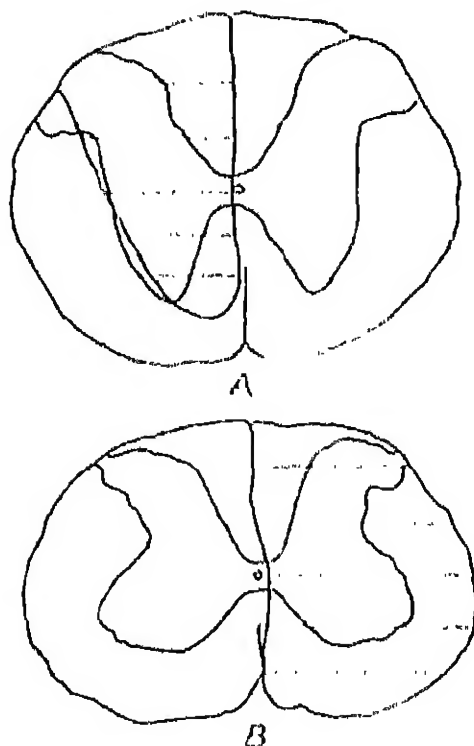


FIGURE 8

dorsum of the left forepaw. For a time after the second operation she lay on her side with all feet sprawled in the air, and, on beginning to walk, she twisted to the left side, frequently falling to that side. At this time the toes of the right forepaw were flexed and both legs on that side were thrust far out to the side as she walked. About two weeks later she had recovered to the point of having a sort of duck-waddle gait, staggering somewhat but not falling frequently. She showed

lack of motor control, which might have been due to proprioceptive disturbances, when first tried on the elevated walk. The latch-box demonstrated quite free use of her left hand, which was the hand most used in the tests with the digging-box.

Head-limb coordinations. She evidenced quite complete recovery of all members except the right forepaw. This was never used for face cleaning after the second operation, but was thrust forward in the face-cleaning gesture. When the vibrissae were taped the hind foot on the right scratched the face and ear region.

Motor learning. Tried on the elevated pathway about five months after the second operation, she did not show much disturbance of locomotion. All feet were kept upon the walk except the right forepaw which slid along the right edge of the path as she progressed. Her nose was always kept near the right edge of the pole, a posture which was an evident factor in balancing. She was very slow in the maze and did not reach the criterion in any case. She was given 100 trials on one side, more than the number required by any other operated case to reach the criterion, and 151 trials on the other side, which was half as many again as any other operated case required to reach the criterion. This was the more surprising in that, after the failure on this problem, she showed very clear evidence of retention of an 8-cul-de-sac maze which had been learned five months earlier after the first operation. Her record on the retention problem indicated a saving of 62% over the original trial record and

about 85% of the original error record. She was slow on the latch-box, although she did learn to operate the mechanism in all different positions. Her time was considerably longer than that of any other operated case.

Why this animal, with not much more severe impairment of the cord than that described for No. 4, had so much difficulty with the learning problems is a question that is not at all clear. It might be attributed to the fact that the lesions in this case were separated by only one segment of cord and therefore would give less opportunity for restoration by means of arcuate channels. This animal seemed always to be in poor physical condition, no matter how well she was fed and cared for. There was evidence of conduction past the block on the right side of the cord. Her greatest difficulty seemed to be in the acquisition of new adaptations such as those which the maze problem and the latch-box offered.

No. 6. Female Albino (used as a normal control on the maze and latch-box previous to operation)

Lesions. The lesion on the left side at the second cervical level was a complete hemisection (Figure 9A). The lesion on the right side at the level of the fifth cervical root (Figure 9B) interrupted the fasciculus gracilis on both sides of the midline, the right fasciculus cuneatus, the right half of the cortico-spinal tract, all of the gray matter on the right, and the dorsal portion of the right lateral funiculus. The only long tracts remaining intact in this cord were the dorsal and

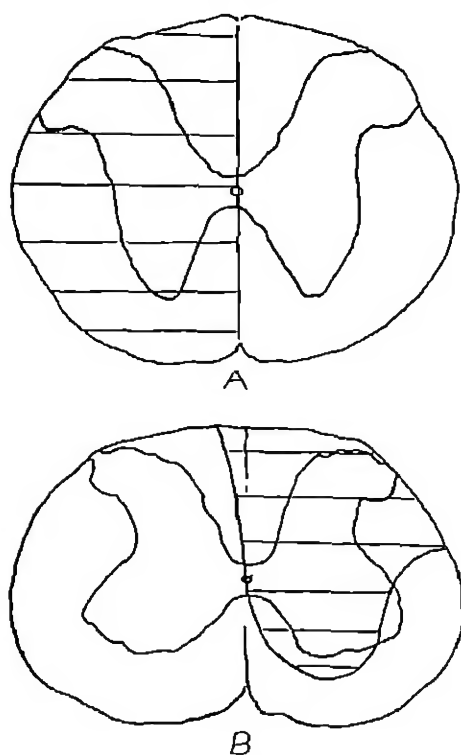


FIGURE 9

ventral spino-cerebellar tracts on the right side. The ventral funiculus on the right had been left almost intact.

Sensitivity. Three months after the second operation she reacted to all types of stimulation on the skin as a normal animal does. Following a series of rather strong faradic stimuli, she would squeal to touching with a pencil point, stroking the hair gently, or to mere contact with the hand.

Motor coordination. Since most other animals had not been tried on the elevated pathway until some time after the second operation, I was most interested to see whether they could adapt to this situation soon after operation. Eight days after her second operation this animal was able to go the distance of one meter without falling to the net. With the hind legs astride the pole, she clung like a sailor on a rope, using the right hind foot, which sometimes made contact with the side of the pole, to propel her body. Her behavior gradually improved for a month or more following this time until she was able to keep her feet on the pole most of the time. The right forepaw was readily used for digging while the left was not very effectually used. In the latch-box the left hand was sometimes brought up to touch the under side of the lever although she always manipulated the lever with the right hand.

Head-limb coordinations. I noted scratching of the right ear with the right hind foot. No such activity on the part of the left hind foot was ever noted. In face washing, although the left hand was cupped and moved coordinately with the right, it never made contact with the mouth. Adhesive tape over the left vibrissae was never removed. The right forepaw was readily used in removing adhesive tape from the right vibrissae.

Motor learning. Retention tests on the latch-box with the lever in the low position in which it had been learned before the operation showed practically no loss in average time of performance. Tried later on the latch-box with the lever in the high position, she

readily learned to manipulate it and always used the right hand in doing so. Her behavior on the elevated pathway has already been described.

This animal, with no long tracts intact except the spino-cerebellar tracts of the right side, demonstrated a rather complete recovery of gross motor functions such as those involved in locomotion, climbing, and maintenance of equilibrium on floor or elevated walk. There was no sign of permanent impairment in cutaneous sensitivity. There were some signs of persistent proprioceptive deficiency. Manipulation of the latch-box mechanisms and the ability to dig through an obstruction were not impaired by the destruction of a large cross-sectional area of the cord. There was evidence of retention of the latch-box habit which had been learned before operation.

No. 7. Female Albino (used as a normal control before operation)

Lesions. The lesion on the left side at the second cervical level had crossed the midline interrupting the fasciculus gracilis on the right side. All of the left half of the cord had been severed except a very small portion of the most medial left fasciculus gracilis and cortico-spinal tracts together with the most medial portion of the median ventral funiculus (Figure 10A). The lesion at the right side in the region of the fifth cervical root (Figure 10B) interrupted the whole right half of the cord with the exception of the fibers of the ventro-lateral funiculus. It is possible that the

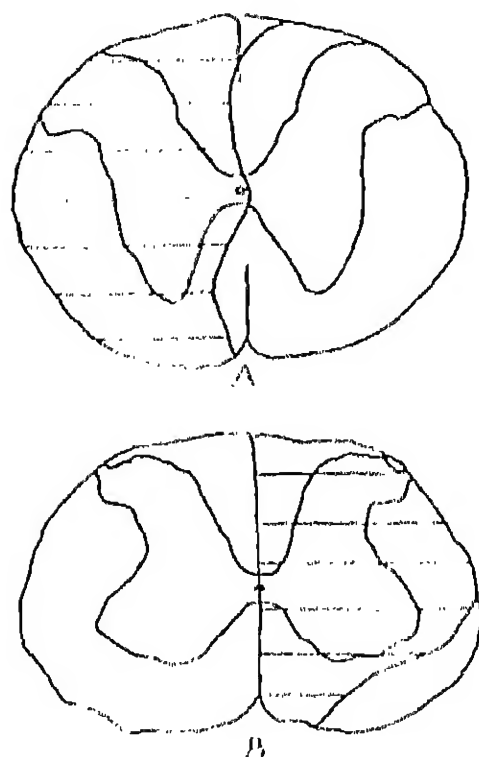


FIGURE 10

only functional long fiber tract in this cord is the right ventral spino-cerebellar tract.

Data. In treatment and observations this animal was an exact parallel of No. 6 described above. So far as her behavior is concerned, there is nothing to add to the account given above except in one instance. I did note use of the left hind leg for scratching in the head region in this animal. The left forepaw showed the same sort of impairment as that already described

for No. 6, that is, it was ineffective in face washing and could not be used to remove adhesive tape from the left vibrissae.

Cortical stimulation. Stimulation of the left cortex produced adduction of the right forepaw and dorsiflexion at the wrist. Stimulation of the right cortex was followed by adduction of the left forepaw and dorsiflexion at the wrist, and, at one time, the foot was very definitely thrust forward. No movements of the hind legs were elicited.

CASES OF DORSAL SECTION IN THE CERVICAL REGION

No. 8. Hooded Female

Lesion. The lesion, which was at the level of the second cervical root, interrupted most of the dorsal half of the cord. All tracts of the dorsal funiculus were cut, together with both dorsal horns of gray matter. There was partial interruption of both rubro-spinal tracts (Figure 11).

Sensitivity. There was evidence of proprioceptive deficiency at first, but this was not permanent.

Motor control. On the first day after the operation the hind legs were spread out from the body at an angle of about 90° and moved in a wide arc as the body was propelled on the table. The hind part of the body was lifted a little. The toes of the forepaws were clasped into fists and the animal sometimes stepped on the dorsum of a forepaw. The hind legs sprawled over the edges of the elevated pathway and were not drawn up. She showed gradual improvement in her walk on a table and on the elevated pathway during the

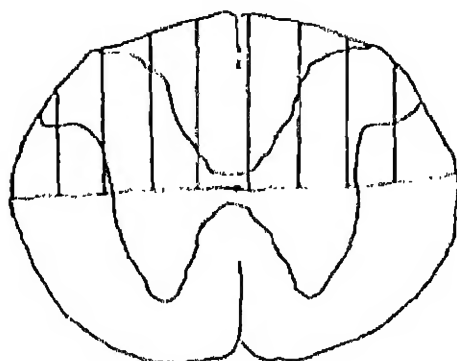


FIGURE 11

following days. For some days the hind feet slipped back when she was walking on a smooth surface and one or the other was dragged now and then. The forepaws were dragged as she swung her body from side to side during the first few days. She sometimes stepped on the dorsum of the forepaws but most frequently the toes were spread as the foot was placed. She gradually obtained better control of all feet and they were brought in closer to the body line in walking. She used either hand or both in manipulating the lever in the high position in the latch-box. She used both hands in digging through shavings to food and seemed to use them equally well.

Head-limb coordinations. She used her hands in clumsy fashion to wash her face shortly after the operation. Within ten days after the operation she readily removed adhesive tape from the vibrissae on either side by the use of the hand on the same side. I frequently observed scratching of head and nose by the hind leg on either side.

Motor learning. On the elevated pathway four days after operation, she managed to move a short distance along it but the movements looked more like swimming than like walking. All feet were astride the pole and their movement made sufficient contact with the pole to cause some progression. Her first trip from end to end of the pole was made in this fashion a few days later. Fifteen days after operation she walked the whole length of the pole without showing much disability. There was some tendency to allow a foot to hang over the side of the pole, particularly when at rest, even up to the time of autopsy. She learned to manipulate the latch-box without difficulty. She was not tried on the maze.

Cortical stimulation. Clear movements of the right forepaw and the right hind foot were obtained in response to stimulation of the left motor cortex. Movements of the left hind limb followed stimulation of the right motor cortex but no clear movements of the left forepaw were obtained.

This animal, with the dorsal funiculus completely severed and some injury to the rubro-spinal tracts of both sides, showed little evidence of permanent impairment so far as the tests used permit of a conclusion. At the end of an observation period of one and one-half months her behavior was in every respect very much like that of a normal animal.

No. 9. Hooded Female

Lesion. The lesion at the second cervical level interrupted both dorsal horns of gray matter, all of

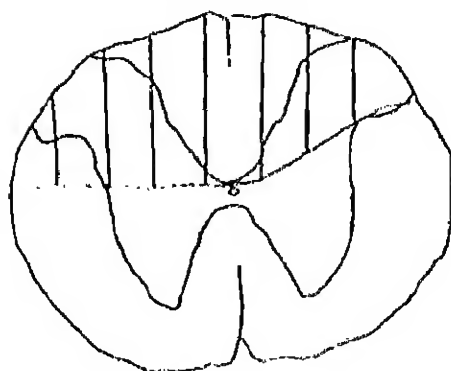


FIGURE 12

the dorsal funiculus, and a portion of the left lateral funiculus. Tracts cut were the fasciculi gracilis and cuneatus of both sides, the cortico-spinal tract, and a part of the rubro-spinal tract on the left side (Figure 12).

Sensitivity. No apparent differences could be discovered between this animal and No. 8 in this respect.

Motor control. In general, motor control was much the same as that reported for No. 8, except that it was restored to a semblance of normal behavior at an earlier date than for the above animal. Her hind legs were not sprawled out from the body so widely as were those of No. 8. On the fourth day after the operation her walk on a table was very much like that of a normal animal. Within 20 days following the operation the only tests that seemed to distinguish her from a normal animal were those on the elevated pathway and on climbing or clinging to a vertical pole.

Control of the hind legs on the elevated pathway seemed to be poor for some time. Otherwise her behavior seemed to be that of a normal animal.

Head-limb coordinations. From the fifth day after the operation face washing was normal and other reactions to stimuli in the head region were normal.

Motor learning. She readily learned to walk the elevated pathway, going the whole distance five days after operation. Control of the hind limbs returned to the point where she was able to walk the path about as well as a normal. She used both front and hind feet in digging through the shavings to food. The latch-box gave her no difficulty since she quickly learned to operate the lever in any position used. Preference for the right hand was indicated.

Cortical stimulation. Good clear movements of the forelegs were obtained in response to stimulation of the motor areas, the left foreleg showing adduction to stimulation of the right cortex and the right foreleg adduction in response to stimulation of the left cortex.

This case, with complete section of the long paths of the dorsal funiculus and injury to the left rubro-spinal tract, showed a marked recovery from injury in a very short time.

CASE OF COMPLETE TRANSVERSE SECTION OF THE CORD

No. 10. Female Albino

Lesions. Histological examination showed complete transection of the cord at the level of the seventh thoracic.

Sensitivity. There was no evidence at any time

after the operation that this animal was sensitive to stimulation on the rear part of the body or the hind legs. Faradic stimulation and break shocks were used in varying strength, pinching, pricking the skin, and pulling hairs. In response to none of these stimuli was there any squealing. When suspended by means of a belt passed about the body, and subjected to stimulation which would cause squealing in a normal animal or in an animal with two sections at different levels of the cord, she would go right on with face washing and give no evidence of emotional disturbance. There was never any cleaning of the rear parts of the body.

Reflexes. Reflexes of the hind limbs were depressed for a short time only after the operation, and then fully recovered. A half hour after the operation there were good reflex movements of the hind limbs. If the animal was suspended, stimulation of one leg would cause flexion in that member and extension in the opposite one. Pinching the tail caused a sort of mass reflex of the whole rear portion of the body. Scratch reflexes of the hind leg would follow stimulation of the corresponding flank or side of the abdomen at about the nipple line. In the early period of observations defecation and urination did not occur without extra stimulation. When the bladder became very full it was automatically emptied. It could be stimulated to empty its contents by stroking the abdomen gently or by tapping over the region of the bladder. Defecation occurred during the early days after operation when the animal was suspended for stimulation of any kind, and while such stimuli were being ap-

plied. This animal was kept for a little more than six months after the operation, during which time intermittent observations were made on her. Elimination of urine and feces became automatic some time after the operation. Mineral oil was used from time to time in order to prevent stasis.

General behavior and recovery data. The animal moved about very readily within a short time after the operation, using the front legs to support the fore part of the body and to propel the body. All activities of the fore part of the body were apparently normal. In locomotion, movements of the hind legs occurred only when some rough surface over which the body passed offered stimulation directly to the abdomen or to the legs themselves. Kicking movements of the hind legs sometimes occurred if the bladder was distended. When the experimenter took the animal and pulled her along on a smooth surface there were no stepping movements of the hind legs. When hanging by the forepaws to a pole she did not move the hind legs in any endeavor to climb up onto the pole. She often climbed up the side of the cage using the forepaws only. There was no evidence of any sensory or motor recovery of the hind limbs so far as "voluntary" control of movements of the rear part of the body was concerned. No evidence was obtained which would indicate passage of an impulse around the block in the cord. This animal was used over a long period of time in an attempt to establish conditioned reflex of the left hind leg. She gave no evidence of conditioning to the

originally indifferent stimulus which was a light contact on the leg.

Cortical stimulation. Clear movements of each of the forepaws were obtained but no movements of the hind legs.

VI

EXPERIMENTAL RESULTS

SUMMARY OF PROTOCOLS IN CASES OF DOUBLE SECTION

Long fiber tracts or parts of such tracts that remained intact are indicated for each animal. Any portion of the ventral funiculi that remained is also described. No. 1 had intact the left ventral and part of the left dorsal spino-cerebellar tract with the medium parts only of the ventral funiculus. In No. 2 the spino-cerebellar tracts on the right, and the left ventral funiculus, were intact. Marginal portions of the right spino-cerebellar tracts, complete left spino-cerebellar tracts, and a small part of the left ventral funiculus were uninjured in No. 3. No. 4 had intact the whole right ventral and lateral funiculi which meant that there was no injury to the right cerebellar tracts or the right rubro-spinal tract. Tracts remaining uninjured in No. 5 were the left rubro-spinal and the left spino-cerebellar tracts. A part of the left ventral funiculus also remained in this animal. No. 6 possessed only the right ventral funiculus and the right spino-cerebellar tracts. Portions not severed in the cord of No. 7 were the right spino-cerebellar tracts and a small median part of the left ventral funiculus.

In no case were there any demonstrated long ascending tracts intact except the spino-cerebellar, and they were confined to one side only with the exception of one case, No. 3, in which the left cerebellar tracts and a small portion of the right cerebellar tracts remained.

Since there are in man spino-olivary, spino-tectal, and spino-thalamic tracts which ascend in the lateral funiculus, it is probable that such tracts or portions of them were intact on one side in six of the seven cases of double cervical section.

Positions of such descending tracts as the vestibulo-spinal, tecto-spinal, and thalamo-spinal, which have been described in man, are not known for the rat, but it is probable that they occupy portions of the lateral and ventral funiculi. Assuming that such tracts exist in the rat and that they are situated as in the cord of man, it is probable that they were functional in some of our cases with double section in the cervical region. The cortico-spinal and Schultz's comma tracts were completely severed in all cases. The rubro-spinal tract was left intact on one side only in two cases, namely, Nos. 4 and 5.

Behavior and Recovery Data

Sensory disturbances. No evidence was obtained for permanent sensory disturbances apart from those which indicated proprioceptive defect except in the case of No. 1 which was apparently analgesic for the period of observation.

The most certain evidence for tactile sensitivity obtained in this study came from cases where electrical stimuli had been applied to various parts of the skin for some time. Following a series of electrical stimuli, squealing could be elicited by touching the animal on either side, stroking the hair, or even blowing on the hairs at some point. Animals showing this type of

response for both sides of the body were Nos. 5 and 6 of the protocols, as well as No. 4 which was used in conditioning experiments. No. 4 had a complete left hemisection; No. 5 had practically complete hemisection of the right side of the cord; and No. 6, a complete hemisection of the left side of the cord. This would seem to indicate that tactile impulses from both sides of the body may pass headward through the intact portions of one side of the cord.

Motor control. Coordinations of limbs for standing, walking, running, and climbing showed a gradual return in all the cases. There was some evidence that Nos. 4 and 5, with rubro-spinal tracts of one side intact in each case, recovered control more readily than other cases where such tracts had been completely severed. Hind limbs were less impaired for locomotion and recovered more quickly than forelimbs. The greatest impairment in the use of the forelimb was always on the side of the most complete lesion. Gross movements were recovered for the forelimb on the side of the most complete lesion in all cases, though the animals were never successful in using this forelimb for movements requiring finer adaptation, such as manipulation of a lever, grasping pieces of food, removal of adhesive tape from the vibrissae of the same side, or for effective face washing.

Comparison of No. 1 with No. 3 furnishes interesting evidence on recovery of finer manipulations of the hand. No. 1 suffered a greater lesion of the cord on the left side than the maximum lesion of No. 3, which was on the right side. No. 3 did not recover the use

of the right hand for finer movements but was able to use the left hand for face washing and manipulation of the latch-box mechanism. No. 1 had a complete lesion of all long tracts on the right side and it was noted that the left hand, in spite of severe injury on that side, recovered sufficiently for face-washing movements. Lack of recovery of the right hand in No. 3 may have been related to the fact that she could more freely use the left hand because of lesser injury on that side, while No. 1, forced to use the left hand in spite of severe injury on that side, showed considerable recovery of the member. This suggests that the degree of recovery is, within limits, less dependent upon the extent of injury than upon compulsory use of the limb.

Locomotion of a sort occurred in all cases within a few days after the second operation and, so far as observations go, the pattern of locomotion seemed to be that of the normal animal. No animal of the seven cases was ever observed to stand on the hind feet in the spontaneous fashion frequently exhibited by the normal animal. That they were able to do this was evidenced by their ability to stand on the hind legs in order to operate the latch-mechanism in the high position.

Head-limb coordinations. Animals with double section carried out body-cleaning operations similar to those of normal animals. They were able to react to the locus of a stimulus applied to the body caudad to the lesions. In all cases the forelimb on the side of the most severe or complete lesion was most impaired, although in cases of complete hemisection the fore-

limb on the same side could be thrust forward in an ineffective face-cleaning gesture if adhesive tape were placed over the vibrissae on that side. No. 4, with a clean left hemisection, was observed to use either the left or the right hind foot in scratching the ear or head. No. 5, with complete right hemisection of the cord, used the right hind foot for scratching the face and ear when adhesive tape had been applied to the vibrissae on the right side. She had quite free use of the left hind foot.

Motor learning. Records of normal animals in learning the simple T-maze are shown in Table 1. The

TABLE 1
INDIVIDUAL RECORDS OF LEARNING ON SIMPLE T-MAZE
NORMAL ANIMALS

Animals trained to go to food at the right side and then to go to food at the left side of the maze.

Rat No.	Maze records			
	Food at right Errors	Trials	Food at left Errors	Trials
11	2	6	8	31
12	7	41	9	16
13	6	16	12	26
15	12	21	10	16
16	7	11	9	16
17	8	31	10	26
18	6	21	9	16
19	8	16	9	16
20	5	11	7	16
21	9	21	8	16
22	9	26	15	26
23	8	16	11	31
24	7	26	13	26
25	6	16	7	26
26	9	21	9	31
27	9	11	12	31
28	7	21	9	31
Mean	7.4	21.3	9.8	23.4

TABLE 2

LEARNING RECORDS OF OPERATED ANIMALS ON SIMPLE T-MAZE
Animals trained to go to food at the right side and then to go to food
at the left side.

Rat No.	Maze records			
	Food at right Errors	Food at right Trials	Food at left Errors	Food at left Trials
2	16	65	18	41
3	41	66	21	91
4	18	56	15	36
5	43	101	37	151
Normal mean	24	51.4	20	53.4

animals were trained to go to food at the right side first, and, upon reaching the criterion, they were started running to the left side of the same apparatus. Table 2 shows the records of four animals with double section in the cervical cord, for the same maze problems. The average normal record is inserted in this table for purposes of comparison with the records of operated animals. In learning to go to food at the right, the operated animals made from two to six times as many errors as the average normal animal, and in learning to go to food at the left side, they again made from two to four times the number of errors made by the average normal animal. Of the operated cases run on the maze problems, one, No. 5, failed to reach the criterion of learning in either case in the number of trials given. She was given 101 runs to the right side and 151 runs to the left side without showing any tendency to cut down her record of about one error per day.

The learning progress on the latch-box is shown for

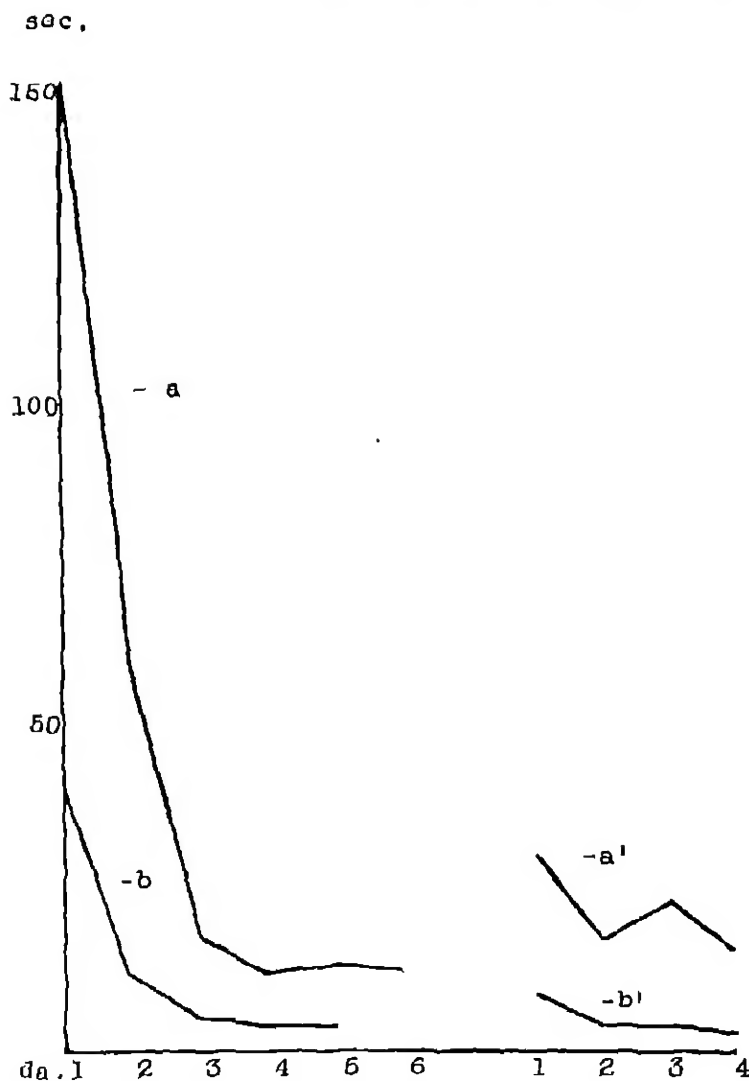


FIGURE 13

LEARNING CURVES, AVERAGE TIME IN SECONDS PER TRIAL ON CONSECUTIVE DAYS, FOR THE LATCH-BOX

a and *a'* for operated animals; *b* and *b'* for normal animals.

normal animals and for double-section cases in Figure 13. Curve 13a shows the learning progress of operated cases on the low latch-mechanism at the left side of

TABLE 3

AVERAGE TIME IN SECONDS OF THE PERFORMANCE OF ANIMALS ON THE LATCH-BOX

Normal controls and cases with double section in the cervical cord.

Rat No.	Latch at left side of door					Latch at right side			
	Days					Days			
	1	2	3	4	5	1	2	3	4
<i>a. Normal Controls</i>									
11	46	10	5	9	5	19	6	3	2
12	18	9	8	6	4	16	6	6	4
13	19	10	4	4	5	7	4	2	
14	21	63	25	5	5	16	9	7	3
15	30	9	6	6		13	8	6	3
16	17	4	1			9	4	2	1
17	31	30	6	4		7	3	1	
18	151	8	5	1		3	3	3	1
19	117	16	3	4	4	4	5	6	3
20	82	12	5	3	2	5	4	1	2
21	75	16	11	5	2	11	6	3	4
22	78	10	4	5	3	4	12	12	5
23	11	4	2			4	2	2	
24	43	15	7	4	3	22	2	3	3
25	36	8	4	3		15	4	1	
26	41	7	4	5	5	6	3	3	
27	13	4	2			4	4	4	2
28	16	14	4	4		9	3	1	
29	26	5	2	2	4	11	3	5	3
<i>b. Operated Cases (Double Cervical Section)</i>									
	Days								
	1	2	3	4	5	6	7	8	
<i>Latch at left side of door</i>									
1	98	24	5	3	5	3			
2	112	24	25	22	8	4	9	5	
3	168	46	24	21	24	10	13	10	
4	68	59	8	5	5	3			
5	309	144	19	17	29	45	21	24	
<i>Latch at right side of door</i>									
1	15	4	4	4	4	3			
2	21	8	8	4	6	5	4		
3	46	24	31	7	29	21	16	12	
4	5	3	3						
5	65	47	78	63	39	33	19	37	

the door while 13*a'* shows their rate of learning for the same mechanism on the right side of the door. Figures 13*b* and 13*b'* tell the same story for normal controls. The records upon which these curves are based are given in Table 3, which gives for each day the average time in seconds of each animal's performance. These records seem to indicate that both groups of animals show about the same relative rate of improvement in performance but that the operated animals do not reach the level of performance of normal animals. Operated cases are definitely slower in their reactions to the latch mechanism, although some operated cases are able to equal normal records.

Two cases with double section, Nos. 6 and 7 described in the protocols, were operated after they had served as normal controls on the problems. Records of their performance on the latch-box made just previous to the first operation, when compared with records made after the operations, show no impairment of ability to operate the mechanism. Records of these cases indicate no greater loss of the habit than that shown by normal animals over an equal period of time. Cases that had learned the latch mechanism after two operations evidenced no loss of the habit after periods as long as three months after original learning.

Table 4 summarizes the evidence regarding lesions, positions of lesions in the cord, maze records, the minimum time in seconds of the best performance on the latch-box, the hand preference for the latch-mechanism, and the hand used in face washing, for the cases with double cervical section of the cord. Records for

TABLE 4
SUMMARY OF DATA, CASES 1-5 INCLUSIVE, OF PROTOCOLS

No.	Tracts intact	Position of lesion (mm level)		Maze records				Min. time (sec.)	Hand used	
		L.	R.	R	Food at R	L	Food at L	Latch-box (sec.)	Latch-box	Face washing
1	pt. v.f. l. v.s.w. pt. l.v.c.	4	2		no record			3	R	L
2	l.v.f. r. s.c. tracts	2	5	66	36	31	36	3	?	R
3	pt. l.v.c. pt. l.v.f. l. s.c. tracts	4	2	66	31	91	21	19	L	L
4	r.v.f. r. s.c. and r. r.c. tracts	5	1	56	18	36	13	5	R	R
5	pt. l.v.f. l. s.c. and l. r.c. tracts	2	4	101	43	151	37	17	L	L

Legend: *r.*, right; *l.*, left; *v.f.*, ventral funiculus; *v.s.w.*, dorsal spinocerebellar; *v.s.c.*, ventral spinocerebellar; *r.c.*, rubrospinal; *pt.*, part.

five cases are given in this table. These are the first five cases described in the protocols.

SUMMARY OF PROTOCOLS IN CASES OF DORSAL SECTION AND COMPLETE TRANSECTION

Dorsal Section in the Cervical Region. The cases of single dorsal section showed practically no permanent symptoms of injury to the cord. There was considerable motor impairment in the first days with little evidence of sensory impairment in these cases, except for proprioceptive control. At the end of a month-and-a-half period of observation they showed no signs of

defect and their general behavior and reactions to tests were quite comparable to those of normal animals.

Complete Section in the Thoracic Region. This case, No. 10 of the protocols, showed no recovery of coordinated movements other than those which can be carried out under the control of isolated spinal segments. There was no evidence for conduction past the lesion, nervous or muscular. Hooker and Nicholas (6) obtained evidence of conduction past a complete break in the cord in newborn rats which had been operated *in utero*. They found no histological evidence for regeneration of the nervous elements of the cord. They explained the conduction in terms of muscular tensions set up which might stimulate proprioceptive fibers leading to intact portions of the cord beyond the block. No evidence of such transmission of impulses either in the cephalad or caudad direction was obtained during the six months and more of observation on this animal. Histological examination showed the lesion to be complete at the seventh thoracic level.

ATTEMPTS AT CONDITIONING

Animals used for this work were a normal rat, No. 4, with double cervical section of the cord, and No. 10 with complete transection of the cord.

The animals were given break-shock stimuli applied to the left hind foot and contact stimuli, touch with the rubber end of a pencil on the thigh from which the hair had been clipped. An indifferent electrode was fastened to the back of the animal and the shock was administered to the left foot.

In the normal animal, although tests were run over a period of two months, there was never any evidence of flexion of the leg in response to touch alone. Repetition of shocks caused emotional excitement which seemed to have a facilitating effect for contact stimuli. The animal squealed in response to a rather large percentage of tactile stimuli after break shocks had been given for some time.

In the case of the completely transected animal there was no apparent effect of the stimulation at any time except for reflex jerking of the foot to the shock. This animal very frequently continued face washing while being stimulated with sufficiently strong shocks to cause violent emotional excitement in the normal animal. The case with double section of the cord responded by squealing, to the same strength of stimulation as did the normal and, after some seven hundred to eight hundred combined stimuli, he began to show a rather definite response to contact on the leg. There was pricking up of the ears and a slight turning of the head to the left side, a kind of air of expectancy, accompanied by squealing in response to about 25% of the tactile stimuli on some days.

VII

DISCUSSION

Afferent and efferent conduction past a double break in the cervical cord of the rat has been demonstrated in cases with complete section of one-half of the cord and interruption of all but the ventral and ventro-lateral funiculi of the other side. The afferent impulses so conducted include protopathic, equal conduction on both sides with complete cervical hemisection; kinaesthetic, in all cases probably impaired, but sufficient to permit walking the elevated pathway; tactile, under emotional facilitation and as evidenced by cleaning reactions for both sides of the body. Efferent impulses include initiation of scratch reflex, hind leg to head, when hemisection was complete on either the same or the opposite side; cleaning reactions, head to body, for both sides; orientation of the body in response to stimulation of the receptors of the head, in maze running; postural coordinations of rising on the hind feet in response to stimulation of the receptors of the head.

The reactions were less perfect than in normal animals, but they show that afferent impulses, tactile and protopathic, can pass a complete hemisection of the cord for the same or for the opposite side. Motor impulses can pass such blocks in the cervical cord, initiating for either side, simple reflexes, coordination between head and limbs in scratch reflexes or cleaning reactions, postural responses and orientation of the body.

THE MECHANISM OF CONDUCTION

What is the mechanism of conduction in these cases?

It may be that the intact connections of one side with the olive, the vestibular nucleus, the cerebellum, the midbrain, and the thalamus, were sufficient to carry out all functions of the limbs of both sides. This seems improbable because it is impossible to correlate either sensory or motor function with the side in which these tracts remained intact. It is improbable because of the evidence for a relationship between recovery and relative extent of lesions on the two sides. Bilateral section of other tracts, the cortico-spinal, rubro-spinal, gracilis, and cuneatus, results in no more evident bilateral disturbance than hemisection. Finally, the observations of Lashley and Ball (7) show no significant symptoms after section of the ventral and ventrolateral funiculi alone.

It may be that there are scattered long fibers in all parts of the cord which normally have all functions. This is not borne out by studies of degeneration. The few long fibers in the major tracts demonstrable by degeneration methods, which have separate origin or termination from the main part of the tract, seem inadequate to carry the mass of excitation involved in complex integrated activities.

It is possible that conduction may be by means of long fibers crossing from one-half of the cord to the other in the interval between the levels of the two sections. Degeneration studies show some such crossing for many tracts but the number of fibers is small in proportion to the bulk of the tracts. Such crossing

fibers cannot explain the phenomena observed in efferent conduction which recovers most rapidly and completely. Evidence against it is furnished by two cases in this study, Nos. 1 and 2, in which the cortico-spinal tracts were completely severed at one level. Lashley and Ball demonstrated that the cortico-spinal tract had been completely severed at one level in some of their cases and that in others the rubro-spinals had been completely severed at one level.

From the evidence now available it seems most probable that conduction in these cases of double section of the cervical cord is through arcuate systems.

CHARACTER OF RECOVERY

The question as to whether this is a normal or vicarious function remains to be answered. It is probable that conduction of all types of impulse must be a normal function of arcuate fibers. Normally it does not play the most important rôle, since reintegration is necessary after establishment of lesions. Rothmann (16) has suggested that phylogenetically old systems remain in the more highly developed species but that the higher centers have developed long and more direct paths for the control of lower centers. In the intact animal both systems function in the integration of movements. He assumes that learned movements are very largely under the control of direct paths from the higher centers, but, in the absence of such direct connections, the control may again be assumed by the more devious routes. The evidence for restitution of the control of movements in the cases studied during the

course of our experiments seems to lend support to the theory of Rothmann.

In these cases it is difficult to state how much of the reacquisition of function which occurs is due to recovery from shock, how much is due to acquisition of function vicariously by previously non-functional or other-functional tracts, and how much is to be attributed to ability to get along without the lost functions.

The picture immediately after the operation and for some time following is one of nearly complete abolition of function. Reflex responses to protopathic stimuli can be obtained a few minutes after the second operation has been completed, although in some cases, and especially in that of No. 1, there is evidence of analgesia. Gross movements of the limbs occur shortly after operation and always on the second day following but they are not well coordinated for some time. Within two to three days after operation the animals exhibit a fair degree of coordination of the limbs in locomotion. Orientation is poor at first but the animal soon learns to avoid obstacles in its path. Coordinated head-limb reflexes, face cleaning, are sometimes exhibited on the day following the operation, although they are not very effective when they first appear. This may indicate that a part of the reacquisition of function is due to recovery from shock.

The performance of the animals on the elevated pathway offers evidence of improvement in sensorimotor control with practice. No matter when they were first exposed to this situation after the operations, and the

variation in time is from six days to two hundred days after double cervical section, the animals had to have a certain amount of practice before they acquired the ability to adapt to such a situation. This holds true as well for maze and latch-box performances, in each of which there were considerable variations in the length of time after operation before the animals were started. Instances of this kind do not point to recovery from shock effects, but they indicate that the remaining connections may be improved through practice at no matter what time they may be exercised.

The animals evidently learn to get along without certain functions which are permanently lost. In all cases they survived and cared for themselves without ability to use one forelimb in finer manipulations. In the case of No. 2, although the right hand recovered sufficiently to be used in face washing, it was not used for manipulation of the latch mechanism. This animal resorted to the use of her mouth when exposed to the situation in which the lever was placed so high that it required reaching up to manipulate it with her hand. Here we have evidence of a substitutional activity which is indicative of learning to get along without a lost function.

Since there are more apparent similarities than differences in the abilities of the animals subjected to two lesions of the cord upon recovery from symptoms of such operations, it would incline one to believe that no matter what particular fibers of the ventral and ventrolateral cervical cord are intact, they may function in about the same capacity. This does not fully answer the question as to whether functions are vicariously

taken over by such cord bridges or whether there is more efficient utilization of residual functions in the portions left intact.

Observations on hemisections of the cord in monkeys led Turner (20) to conclude that "as no regeneration took place at the seat of the lesion in these experiments, the impressions were probably conveyed to the parts below the lesion by the opening up of decussating paths from the opposite uninjured side" (p. 517). After having noted the return of sensory function on both sides in cases of hemisection of the cord he stated that "it appears that in the monkey at any rate, owing probably to the less highly organized state of its spinal cord, restitution of the sensory functions occurs at a much earlier date after infliction of an injury than obtains in the highly organized cord of man" (p. 518).

Indications are that temporary shock effects play some part in the recovery of the animals but that a large part of the recovery comes about through a more efficient utilization of the remaining fiber tracts of one side of the cord which is the consequence of spontaneous use and forced exercise.

MECHANISMS OF RECOVERY

Some evidence has been obtained in this study as to the mechanisms concerned in recovery. No. 10, with complete transection of the cord at the level of the seventh thoracic root, has demonstrated the limited capacity of recovery in isolated segments of the cord. There was no recovery of movements except those of a purely local reflex nature and, at no time, any evidence

of conduction past the complete break in the cord. There was never any sign of coordination of movements of the hind limbs with those of the forelimbs in this animal.

It is possible that the necessity of conduction past the break is a factor in recovery. Necessity for practice of a limb may have an influence in its recovery. The work of Oden and Franz (11) has shown that little recovery took place in paralyzed members unless they were subjected to special treatment and forced into use. No. 3, of our double cervical cases, with the minimal lesion on the left side, used the left forepaw for finer movements and showed no recovery of the right forepaw for such activities. The lesion on the right side in No. 3 was no greater than the lesion on the left side in No. 1 who recovered the use of her left forepaw for face washing. That this recovery took place in No. 1 may be due to the fact that all long tracts on the right side of the cord had been completely severed in this animal. Exercise achieved as a consequence of stimuli applied to the body and head may have been a factor in more ready adaptation on the part of other animals as well. Definite efforts were made to excite head reactions to the body as well as to stimulate limb reactions to the head. The fact that any reaction was obtained in the first place, however, indicates that paths for the passage of such impulses must have been open from the beginning.

There are indications that recovery may be related to the length of the intervening segment of the cord between the two lesions. Nos. 3 and 5, each with lesions

in the second and fourth cervical root levels, remained slow in movements generally and showed the poorest records of all in the maze and latch-box. The failure of No. 5 to adapt to the simple maze is the more surprising in view of the fact that she was able to relearn an 8 cul-de-sac maze without much evidence of loss, after her failure on the simple maze. It was most difficult to keep these two animals in good physical condition, no matter how well they were cared for. On the other hand, No. 4, with lesions exactly similar to those of No. 5 except that they were more widely separated, gave evidence of much better control of movements generally and made much better maze and latch-box records. No. 2, with lesions in the second and fifth cervical root regions, also affords evidence that separation may be a factor in recovery. Her performance on the maze and latch-box closely approaches that of No. 4 even though her lesions were more severe. The only contradictory evidence furnished is that of No. 1 whose lesions were more severe and no farther separated than those of Nos. 3 and 5. Her performance on the latch-box, so far as time records are reliable, was closely similar to that of Nos. 2 and 4. Unfortunately, maze records were not obtained for this animal.

Some bits of evidence seem to point to a relation between defects and completeness of section. No. 1, with very severe section, seemed to give the clearest evidence of protopathic disturbance, but this observation was for only a short period after the lesions were established. Two cases, Nos. 4 and 5, in which the rubro-spinal

tracts of one side were intact, seemed to have the least difficulty in adjustment to the elevated pathway. Considering the two lesions in the same animal, it was evident that recovery of finer manipulations of the forearm occurred on the side of the least complete lesion.

That emotional reinforcement may be a factor in passage of the block by impulses has been indicated by observations on several cases of double cervical section. As previously noted, responses to tactile stimulation are difficult to interpret in the rat. It was found fairly easy to elicit squealing to contact stimuli on the parts of the body caudad to the lesions when the animal had previously been subjected to moderately strong faradic stimulation on the body and limbs. This reinforcement was evident for some little time after a series of faradic stimuli had been given. The fact that emotional reinforcement seems to operate under such a condition may have some relation to recovery by a process of irradiation or spreading of the effects of localized stimuli.

MODIFIABILITY IN SEPARATE SPINAL SEGMENTS

The work done on conditioning in this study has afforded no evidence for conditioning or modifiability of isolated spinal segments. There is some evidence of conditioning or facilitation in cases where a limited connection remains with the head region. Further investigation of this question is necessary before any conclusion can be drawn about the possibility of establishing conditioned reflexes in animals with double cervical section of the cord.

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LES MÉCANISMES COORDONNANTS DE LA MOTILITÉ SPINALE

(Résumé)

On a fait cette étude dans le but d'établir de l'évidence relative aux problèmes de la conduction spinale et de la récupération des effets des lésions dans la moelle épinière. On a fait usage des rats adultes albinos et pigmentés. On a fait subir des lésions de la moelle aux animaux. On a préparé quelques cas avec une hémisection double de la moelle cervicale, d'autres avec une section de la colonne dorsale et des fibres radiales dorsales seulement; ou cas avec une section complète de la moelle au septième niveau thoracique.

On a fait des observations de la température corporelle et rectale. On a fait des tests de sensibilité à divers temps après les opérations. On a fait des observations de la récupération du contrôle moteur dans la station debout, la marche, la course, l'action de grimper, et l'action de sauter. On a fait des tests des coordinations de la tête et des membres. On a testé l'apprentissage moteur au moyen d'un parcours élevé, d'un labyrinthe simple en forme de T, et de la "tatchbox." On a essayé d'établir des réflexes conditionnels.

Des tableaux dans le texte montrent l'étendue des lésions dans les animaux individuels employés dans cette étude.

La conduction afférente et efférente au delà d'une cassure double dans la moelle cervicale du rat s'est montrée dans des cas avec une section complète de la moelle et l'interception de tous les fasciculi, tant les ventraux et les ventro-latéraux de l'autre côté. Les impulsions afférentes ainsi conduites comprennent une conduction post-opératoire égale des deux côtés avec une hémisection cervicale complète, kinesthésique, dans tous les cas probablement affaiblie, mais suffisante pour permettre aux animaux de marcher sur le parcours élevé; tactile, sous la facilitation endomusculaire et montrée par des réactions de nettoyage pour les deux côtés du corps. Les impulsions efférentes comprennent: l'initiation du réflexe de gratter, la jambe de derrière à la tête, avec une hémisection complète du même côté ou du côté contraire; des réactions de nettoyage, la tête au corps, des deux côtés; l'orientation du corps en réponse à la stimulation des récepteurs de la tête, dans le parcours du labyrinthe; des coordinations posturales de se lever sur les pattes de derrière en réponse à la stimulation des récepteurs de la tête.

Les segments isolés de la moelle montrent la récupération des réflexes locaux seulement avec nulle évidence de la conduction au-delà de la cassure dans la moelle. Il n'y a nulle évidence de conditionnement dans la moelle isolée et très peu d'évidence dans les conditions de l'expérience, dans le cas avec une section double de la moelle ou dans l'animal normal. Les animaux avec une section de la portion dorsale de la moelle cervicale montrent très peu d'évidence de symptômes permanents.

On a fait des suggestions à l'égard des mécanismes de conduction et de la récupération dans les cas de la section double de la moelle cervicale.

EXPERIMENTS

DIE KOORDINATIONSMECHANISMEN DES RÜCKENMARKS

(Referat)

Es war der Plan dieser Untersuchung, die Aufgaben der Rückenmarksleitung [spinal conduction] und der Genesung von den Einwirkungen von Verletzungen des Rückenmarks experimentell zu behelfen. Es wurden erwachsene Albinoratten und behaubte Ratten verwendet. Es wurden an den Tieren Verletzungen des Rückenmarks ausgeführt. Einige Fälle wurden mit doppeltem Halbschnitt des Nackenmarks präpariert, einige mit Schnitt bloss der Dorsalsäule und der Stränge der Dorsalwurzel; in einem einzelnen Fall wurde das Rückenmark am Niveau des siebenten Brustnerves vollkommen durchschnitten.

Es wurden Beobachtungen gemacht an der sensorischen und motorischen Wiederherstellung. Es wurden, zu verschiedenen Zeiten nach den Operationen, Prüfungen der Empfindung [sensitivity] gemacht. Es wurden Beobachtungen gemacht an der Wiederherstellung der motorischen Beherrschung des Stehens, des Gehens, des Laufens, des Kletterns, und des Grabens. Es wurden Prüfungen der Zusammenwirkung [coordination] zwischen Kopf und Glied gemacht. Man prüfte die motorische Lernfähigkeit mit einem erhöhten Geleise [elevated runway], mit einem einfachen T-Labyrinth [T-maze], und mit dem Klinkkasten [latch-box]. Man versuchte, bedingte Reflexe zu bilden.

Figuren in Text weisen auf den Umfang der Schädigungen bei den einzelnen, in dieser Untersuchung verwendeten, Tiere hin.

Die afferente und efferente Leitung über einen doppelten Bruch des Rückenmarks der Ratte ist in Fällen demonstriert worden, in denen die eine Hälfte des Rückenmarks vollständig getrennt worden war und in denen auf der anderen Seite alle Funiculi mit Ausnahme der ventralen und ventrolateralen in ihrer Leitung unterbrochen worden waren. Die auf diese Weise weitergeleiteten afferenten Impulse sind u.n.: (1) Protopathische: Gleiche Leitung auf beiden Seiten bei vollständiger Hemisektion des Nackenmarks; (2) Kinesthetische: In allen Fällen wahrscheinlich beeinträchtigt, aber genügend zur Ermöglichung des Gehens auf dem erhöhten Geleise; (3) Tastimpulse: zeigen sich unter Einwirkung der affektiven Bahnung [facilitation] und werden an Reinigungsreaktionen auf beiden Seiten des Körpers erwiesen. Die erwiesenen efferenten Impulse schliessen in sich ein: Einleitung des Kratzreflexes (Hinterfuss an den Kopf), bei vollständiger Hemisektion entweder der selben oder der entgegengesetzten Seite; Reinigungsreaktionen (Kopf an den Körper) auf beiden Seiten; Orientierung des Körpers als Erwiderung auf Reizung der Rezeptoren des Kopfes beim Labyrinthlaufen; Haltungskoordinationen [postural coordinations] des Sich-Erhebens auf den Hinterbeinen als Reaktion auf Reizung der Rezeptoren des Kopfes.

Isolierte Segmente des Rückenmarks erweisen Wiederherstellung der lokalen Reflexe allein, ohne Beweis der Leitung über den Bruch im Rückenmark. Man erhielt keinen Beweis der Bedingung im isolierten Rückenmark und wenig Beweis für die Bedingung sowohl bei doppelter Sektion des Rückenmarks wie beim normalen Tiere, unter den Bedingungen dieser Untersuchung. Tiere mit Sektion des dorsalen Teils des Nackenmarks geben wenig Beweis dauernder Symptome.

Es sind Anweisungen gegeben worden in Bezug auf die Mechanismen der Leitung und der Genesung in der Fällen doppelter Sektion des Nackenmarks.